THE

Journal of Electricity, Power and Gas

WITH WHICH IS INCORPORATED

The Engineers' Architects' and Builders' News

VOLUME XVII. SAN FRANCISCO, CAL., SEPTEMBER 8, 1906 No. 10

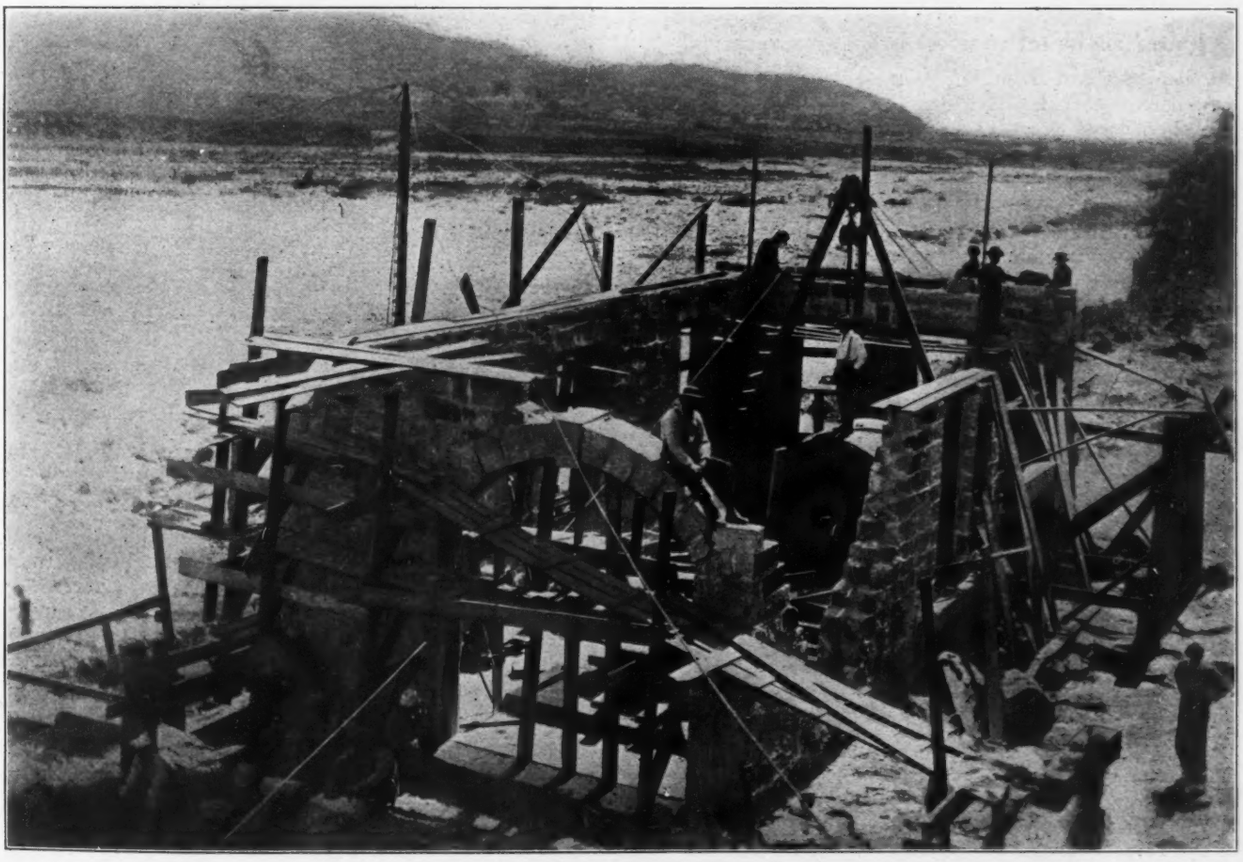
A Korean Hydro-Electric Transmission Plant.

BY WM. M. DEAN.

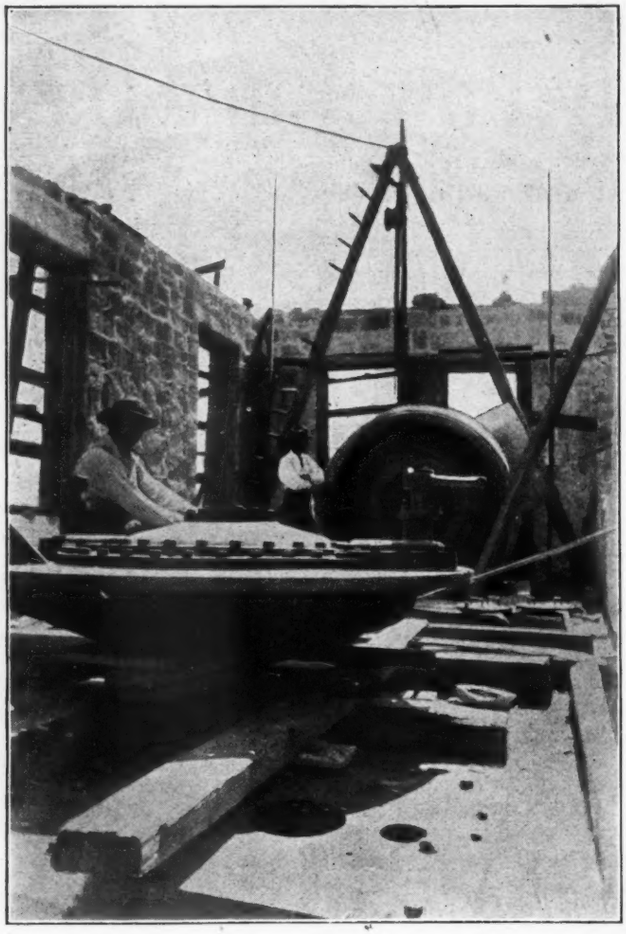
The electric light and power plant of the Oriental Consolidated Mining Company, of Wunsan, Korea, is, perhaps, one of the most important electrical installations ever built for mining purposes in the "Hermit Kingdom." While the plant is not materially different from that of many similar installations on the Pacific Coast, yet the conditions under which it was built are not only interesting, but indicate the necessity of considering the particular conditions existing in connection with every installation.

The plant of the Mariposa Commercial and Mining Company, on the Merced River, in Mariposa County, had been in operation but a short time when it was decided by the Oriental Consolidated Mining Company to install a similar plant for their mines in Korea. The two companies, having practically the same management, decided that if a water power plant could so materially reduce their cost of operation in California, the same should be true in Korea. The result has fulfilled every expectation of the company.

On the 9th of November, 1904, I sailed from San Francisco on the steamer Doric, bound for Chemulpo, Korea, the nearest seaport to the mines, having been commissioned by the firm of Cory, Meredith & Allen, consulting engineers, to supervise the installation of the complete plant. The machinery had all been shipped from New York, and was to have been on the ground upon my arrival. The trip of twenty-seven days, which included stops at Honolulu, Yokohama and Kobe, was a most delightful one, and at the latter place we were transferred to a little Japanese steamer, which completed our trip to Chemulpo. After a day's sightseeing in that interesting but filthy seaport, we continued our journey on up to Chennampo, where we met a party from the mines en route to Chemulpo, bringing down a small fortune in gold bullion. We joined them on their return trip, starting out overland into the interior of Northern Korea for a journey of approximately 160 miles. My wife, who accompanied me on the trip, was carried in a Sedan hcair by four stalwart, professional coolies, while I was allowed to jog along astride a Korean pony, whose diminutive height scarcely allowed my feet to clear the ground. Naturally, this trip was full of experiences, both pleasant and otherwise, but



EXTERIOR OF POWER HOUSE DURING CONSTRUCTION.



INTERIOR OF POWER HOUSE DURING CONSTRUCTION.

the main fact is that the ride of three days and three nights is well remembered, principally on account of the hardships we experienced. We slept on the floors of the small, vermin-infested, mud houses and ate queer food prepared for us by dirty native inn-keepers.

At last, however, we arrived at Chittabalbie, the first mining camp of the company. Here we were royally received by the men of the mining camp, who are mostly Americans, and were more than cheered up by a good American supper and a sleep in a modern and most acceptable spring bed. The next morning we started in a heavy snow storm for the last stage of our journey, which was but twenty miles to Taracol, where we arrived at 4 o'clock in the afternoon, and found a small, but very comfortable Korean house reserved for our use. In this house we lived during our stay at the mines, and everything was done to make us comfortable.

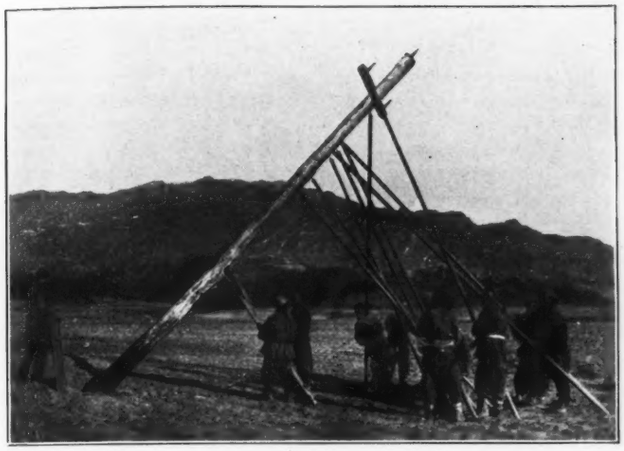
The Oriental Consolidated Mining Company's concession from the Korean Government embraces sixty square miles for mining purposes, and its northern boundary is but forty miles in a direct line from the Yalu River, the Manchurian boundary. In this territory are situated five mining camps, with mills containing an aggregate of three hundred stamps. These mills have for a long time been operated with steam power, but as fuel, which is wood, was becoming very scarce, it was deemed advisable to utilize the water power near Taracol to generate electric power for milling purposes. A dam had already been practically completed upon my arrival; the hydraulic development, consisting of a ditch and flume about three miles in length to the power house site, was also nearly completed. The dam above referred to was located at a most advantageous point, about five miles south of the Taracol camp.

Referring to the details of construction, I found great difficulty in securing poles for the transmission line, as they had to be cut far away in the mountains and hauled in on bull-carts over almost impassable roads. I succeeded, however, in contracting for a sufficient quantity of beach, maple and oak sticks, twenty-five feet long, exceedingly crooked and extraordinarily heavy. The transmission line is but five miles in length, and these sticks or poles were spaced on an average of forty to fifty to the mile. In lieu of the modern treatment with Carbolineum or crude oil, the butts of the poles were burned before being set, in order to, as much as possible, preserve them from early decay.

To begin with, the labor situation had to be considered. After considerable effort, I obtained a large force of Korean coolies, paying them the magnificent sum of twenty cents a day per man. The first work they did was to dig the pole holes, and as I found the Koreans exceptionally efficient for this work, the actual cost of labor for this purpose was exceedingly small. These men are natural miners, and are very clever in handling rocks, thereby saving much time and expense in drilling and blasting.

Upon beginning the work of raising the poles, however, I found that these same Koreans were practically worthless, and after considerable negotiation, hired a crew of Manchurian Chinamen. They were all big, well-built men, who, after the first few poles had been raised and tamped in, went ahead with the work without further instruction or supervision. At the time the pole line was built, the ground was frozen to a depth of two or three feet, and it was necessary to build fires over each pole hole location before any digging could be done.

"PAK" MY CHINESE FOREMAN AND CHINESE INTERPRETER.



CHINAMEN WORKING ON TRANSMISSION LINE.

As I look back upon my experience, I see how fortunate I was in having assigned to me a very intelligent Korean foreman and interpreter, who could speak Chinese, Japanese and English, all three as well as his own language. Throughout my work in Korea he was of inestimable assistance to me, and I beg here to pay tribute to "Pak" for his faithfulness and constant efforts in my behalf. I also had with me one or two other Koreans, who were more progressive and intelligent than the average of their race. These men readily learned to climb poles, and were later used as linemen.

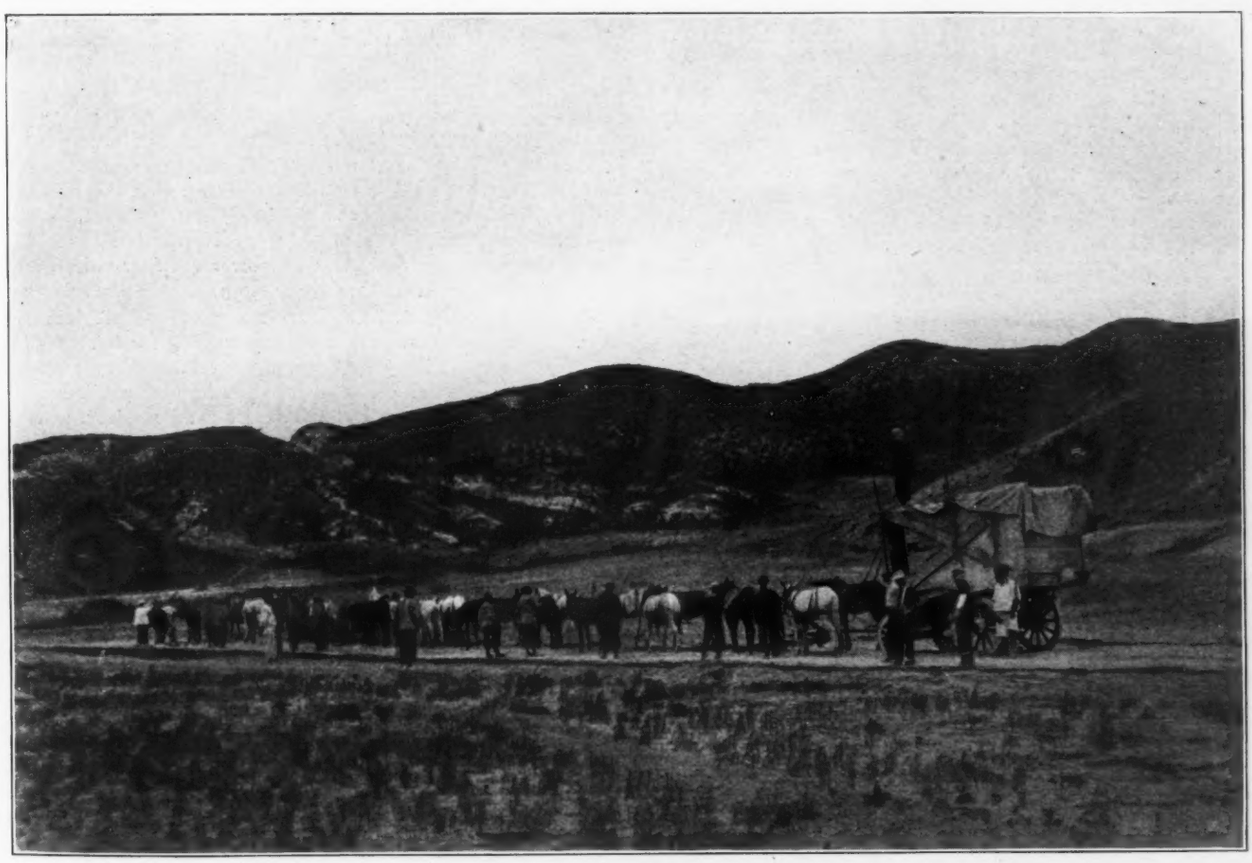
The transmission line and sub-stations were completed and the transformers installed before the water wheels and generators arrived from New York. The last work undertaken, therefore, was to build the power house and install the hydraulic and electrical machinery. Since the winters in Korea are severe and the roads practically impassable during the winter months, it was late in the Spring of 1905 before it was possible to begin the foundation for the power house. By this time I had secured a force of Chinese stone masons from Che Fu, China, who quarried out and dressed up the stone for the power house building. We were fortunate in finding the stone near the power house site, and it was but necessary to quarry and cut it to the proper shape in building the power house.

While work was progressing upon the generating station, the ditch and penstock were completed and the pipe line rivited in place, Japanese blacksmiths doing the work, to which they seemed particularly adapted.

The equipment of the power house consists of a Stilwell-Bierce Victor turbine, operating under 110 feet head, direct connected to a 500-kilowatt, 13,000-volt, rotating field, 3-phase alternator, manufactured by the General Electric Company. The pipe line was 48 inches in diameter and approximately 325 feet long. The heavy parts of the water wheel and generator were hauled sixty miles from An Ju, which is the head of navigation on the An Ju River. American wagons of the heaviest construction, requiring thirty-six mules to each wagon, were used to transport all of the machinery.

The entire plant equipment was somewhat the worse for the wear when it arrived in August. The transformers which had been delivered during the winter were also in bad shape, being full of ice and soaked with water. It was, therefore, necessary to dry them out in a hot, closed room for many days. The power house was completed, machinery installed, and the plant started October 1st, the induction motors furnishing the power for driving the mills in a most satisfactory manner.

We had been somewhat delayed by the breaking of the dam at Shorrie, but water sufficient to run the plant had been diverted into an auxiliary ditch from the Puk Chin River,



FREIGHTING THE MACHINERY OVERLAND.

and with the exception of the burning out of one of the transformers, which had been damaged in shipment, the plant ran most satisfactorily from the start, until one of the native operators strayed from his post of duty, allowing the water wheels to race. The result was that the voltage increased to a point where an arc was formed across the feeders and instruments in the sub-way, and set fire to the entire installation below the floor line. Fortunately, there was an extra supply of cable and other supplies for repairs, so that in a few hours the plant was again in operation, and was still running to its full capacity when I left Korea in November, 1905.

The plant has resulted in such a saving in the operation of the mines that it is proposed to extend the power service to some of the lower mining camps as soon as their hydraulic development is completed, and the company can rely on a sufficient supply of water. The conditions for operating a water power electric plant in Korea are very similar to those found in Northern California, as the seasons are about the same, and atmospheric conditions of a similar character. Except for the difficulty of getting competent operators, an installation of this character in Korea is not materially different from that of a similar plant in California.

The American mines are splendidly equipped. I found a good machine shop, presided over by a competent American machinist, while as good a blacksmith shop is under the expert management of a Japanese blacksmith, who seemed to be able to make anything from a needle to an anchor. I also found a fair sized foundry, which turned out ordinary castings of very good quality. In this way damaged parts to the iron or brass parts of the machinery can be readily duplicated. There are, of course, many inconveniences to be contended with in a place so remote from supplies of every character, and it keeps one constantly scheming to overcome the obstacles presented at every turn, particularly in connection with construction work.

As far as labor is concerned, I found the Chinese preferable in most lines of work to the Koreans or Japanese, as they could be relied upon to do as they were told, and not "soldier" when the foreman's back was turned.

Naturally, I found no unions, but I did experience one strike. This was among the Chinese stone masons, who asked for an advance of five cents per day. The strike was settled immediately by my discharging the entire crew, who thereupon laughingly picked up their tools and went back to work. The Koreans are proverbially the laziest race in the Orient, but by constantly standing over them and using sufficient urging, it is possible to get four of them to do the work which should be done by an ordinary white man.

Considerable difficulty was also experienced on account of the heavy rains. During the summer months the precipitation is so great and so concentrated that the streams are all torrential. When the bridges are most needed, the natives take them down to save them from being washed away. These bridges lie upon the river bank until the coming of dry weather, when they are put back. The rivers during the rainy season are almost unfordable, therefore, preventing the bringing in of perishable goods which would be in any measure damaged by water. The revolving field of the generator, as an example, was turned over in the river while it was being hauled across one of the bridges, and it was the exception when any of the machinery, upon arrival at the plant was found to be free from a thorough soaking, either due to rain or accident.

San Bernardino, Cal.——A. C. Denman, Jr., has presented two applications for franchises, one for right of way for extension out to the Arrow Head Sanitarium, and the other for the practical closing of B street through the Arrow Head tract by slicing off 60 feet from each side of the street for private right of way for the traction company.

STREET LIGHTING.

One of the most complete investigations into the matter of street lighting by both gas and electricity has recently been made by H. T. Harrison, who has given the results of his experiments in an article recently published in the Journal of the Institution of Electrical Engineers of England. The commercial value of the paper is such that the results should be very carefully considered by every public corporation and also all municipalities directly interested in the subject. The general conclusions and other data are included in the following abstract of the paper:

Everyone can judge illumination with his own eyes, but, in order that his judgment may be of any practical value, his eyes will require assistance in the form of a photometer. Both gas engineers and electrical engineers are taught to use this instrument, but I have never heard that its manipulation is included in the education of any one belonging to the professions and trades from which the representatives of our boroughs, cities or towns are generally drawn; therefore, if the engineers could be persuaded to use photometers for the purpose of measuring illumination which cannot be accurately measured in any other way, and if committees could be persuaded to make use of these measurements when they are made, the result would be that the rate-payers would benefit, not only financially by the reduction of the lighting rate, but also by the increased comfort which would result from the better illumination of the streets.

The antipathy which engineers have so far shown to the actual measurement of street illumination is in the case of gas engineers, and to a smaller extent in the case of electrical engineers, due to the fact that they are in the habit of stating the value of a lamp as the candle-power which it will give when measured in the best position and without any globes or lanterns; therefore, when measuring street illumination a figure is generally obtained much lower than that claimed; but it is this actual figure which must be used for comparative purposes, and, as I have suggested above, electrical engineers have much less to fear than gas engineers from this exposure.

For instance, a Welsbach mantle consuming from 3.5 to 3.75 cubic feet per hour is generally stated as 70 candle-power, whereas the very large number of measurements I have made during the last few years have shown that the average candle-power derived, when measured in the street, is 35! Again, a 200-volt, ½-ampere "A" type Nernst lamp, according to the makers, gives 70 candle-power (heffner units), and in practice I have found them equal to 37 candle-power!

Again, a 500-watt, direct-current, open-type arc lamp is generally called a 1,000 candle-power lamp; whereas Mr. Bradley's tests and my own go to prove that they average 600 candle-power. Another example is the new gas lamps in Fleet street, which were claimed as 200 candle-power, whereas the actual measurements I have made prove that they average 135 candle-power.

Another example is the much-advertised gas lighting in Kingsway and Aldwych. The gas journals are continually referring to the lamps used as 1,000 candle-power, whereas the average of a large number of photometric measurements made by myself and others prove that the average candle-power in the street is 515.

I think these examples sufficient basis for the opinion I have formed as to the reason why gas engineers avoid the photometer and prefer to rely upon verbal or written statements which they trust never to be called upon to verify.

I do not wish you to go away with the idea that I place no value on public opinion of street lighting; I know that the residents in any town or street could tell you whether its illumination is sufficient for their purpose, because they have to use the light and judge accordingly. But to take any individual and ask him to give an opinion on the value of two illuminants—which do not, probably, vary more than 50 per

cent—is pure waste of time, unless he uses suitable instruments, or has made a special study of the subject.

In order to arrive at any decision as to the degree of illumination which may be considered efficient for various streets it is necessary to decide first the units in which the value of illumination should be specified. I have had the opportunity of examining several reports which have been submitted by engineers to lighting committees; in the majority of these it has been considered sufficient to state the candle-power of the lamps in the same way as Mr. Bradley does in the most valuable tests he makes periodically in Westminster; others have gone a little further, inasmuch as they state the candle-power per mile of road; others, again, have based their figures on various illumination tables given in candle-power feet at various distances from the source of light.

That none of these methods are complete enough will be obvious when an attempt is made to compare the reports. For instance, the mean illumination of a street cannot be ascertained from measurements of candle-power unless these are taken at a large number of different angles, because there is practically no source of artificial light which gives a true hemispherical candle-power; by that I mean a light of which the candle-power measured at any of the angles in the lower hemisphere will be approximately equal. Moreover, it is necessary to state the height and distance of the lamps, in order to judge the illumination derived.

In 1892 Mr. Trotter read a paper* which dealt very fully with this matter, and his paper is even now probably the most complete treatise extant on the subject. Many members will remember Mr. Trotter's paper, and no doubt use it for reference, but for the benefit of those who have not seen it I propose to give a short resume, in order that I may point out the reasons which, in my opinion, have prevented his proposed system of measurements from becoming generally adopted.

Mr. Trotter used an illumination photometer devised by himself, in conjunction with Sir William Preece, by which the horizontal illumination at various parts of the road could be measured; and incidentally he gave it as his opinion that the nearer this illumination could be measured to the road surface the better.

Now, it is obvious that if the degree of illumination is measured on a horizontal plane, all the lamps in the neighborhood of the photometer will assist in illuminating that plane, therefore the spacing and height of the lamps can be disregarded when making comparison, and only the measurements in candle-power feet taken into consideration; and if the mean of these measurements could be taken as a criterion of the illumination of the road, no better system could be adopted. Mr. Trotter shows at great length in his paper how this can be done by plotting a large number of contour curves and illumination curves along imaginary lines drawn down a street; but unless sufficient measurements are made to plot these curves in every case, and a mean illumination obtained by dividing the plan of the street into a large number of subdivisions and taking a mean of all the various degrees of illumination in all the subdivisions, as shown by the contour curves, I fail to see how the mean degree of illumination can be arrived at.

As the above process would entail more time than can generally be given to this branch of work, I would not advise anybody to attempt it. Moreover, there are other practical objections to the use of an illumination photometer as described by Mr. Trotter, which eventually resulted in my abandoning its use, but not until I had had practical experience of it for a period of about two years, and had obtained results of considerable value to me in my study of street lighting.

* Minutes of Proc. of Inst. of Civil Engineers, vol. cx., 1892, p. 69.

These practical objections were the following:

The large difference between the maximum and minimum illumination when measured on a horizontal plane, coupled with the small range of the instrument, made it only possible to survey the illumination over a very small portion of the street unless several different standard lamps are used, and even then the instrument was found to be difficult to balance when a comparatively high or low degree of illumination was being measured.

Thus I came to the conclusion some time back that in order to encourage more general testing of street illumination for comparative and specification purposes, a simpler means would have to be adopted than has hitherto been the general practice, and that an instrument must be devised by which the degree of illumination of a street could be rapidly and accurately determined. I am now able to show the design of instrument I consider most suitable, but before discussing it I propose to define the measurements which I have come to the conclusion are necessary.

In order to judge the lighting of a street it is only necessary to know the minimum illumination at any point where light is required, because if that illumination is sufficient for the purpose it obviously follows that it will be ample elsewhere; to go to great trouble in order to obtain an average illumination is not only sheer waste of time, but also misleading; for example, the average illumination of a street brilliantly lighted in one part and left in comparative darkness in another part may be high, but it is of no practical use except that you know that by moving from one brilliantly lighted spot to another you will travel along the street, provided you do not encounter any unseen objects or dangers in the dark intermediate parts; therefore, I think you will agree with me in saying that the measure of minimum illumination is of primary importance, and on its value the efficiency of the lighting of the street depends.

It will probably be suggested that the value of the maximum illumination should also be measured and stated, in order that a diversity factor may be arrived at. This is to some extent true, as passengers in vehicles passing rapidly along a street having a large diversity of illumination are liable to become dazzled; moreover, the value of the minimum is reduced if the iris of the eye is being periodically contracted by brilliant patches of light. Therefore, I think we may take it that the best lighted streets are those with the highest minimum illumination and with the lowest diversity factor, and, after having granted this definition, all that remains to be done in comparing the lighting of various streets is to state the value of the maximum and minimum illumination as measured therein.

But the unit of illumination, namely, the candle-power foot, is not sufficiently definite, for it is obvious that when speaking of illumination we really mean the degree to which something is illuminated, and that will depend to a very large extent on the average angle at which the light strikes the various surfaces of that object.

Mr. Trotter, with his illumination photometer, chose to measure illumination on a horizontal surface, and it has become very common to state (as Mr. Hoadley did in his paper read before the Municipal Electrical Association this year) the measurements in candle-power feet, disregarding the angle of the screen on which the illumination was measured.

I have, therefore, prepared the following table (I.) of illumination on planes at various angles to demonstrate the error which might follow if this important factor in the unit is disregarded. This table also emphasizes the decision to which I have come regarding the most suitable angle of the screen on which to make these measurements.

For the sake of simplicity I have taken the light as being 1,000 candle-power in all directions and at a height of ten feet above the measuring screen:

TABLE I.

ILLUMINATION IN C. P. FEET ON SCREENS FIXED AT VARIOUS ANGLES.

Distance in Feet.	Direct.	Horizontal.	Vertical.	At 45°.
0 Illumination	10	10	0	7.70
5 "	8.0	7.15	3.5	7·0
10 "	5.0	3.5	3.8	5·0
15 "	3.0	1.7	3.5	2·9
20 "	2.0	.9	3.1	1·88
30 "	1.0	.31	1.7	·88
40 "	.58	.14	.57	·5
50 "	.38	.075	.26	·32
60 "	.27	.044	.19	·2
70 "	.20	.028	.15	·158
80 "	.15	.019	.12	.120
90 "	.12	.013	.098	.094
100 "	.09	.001	.081	.076

It is, of course, unnecessary to remind the members that the illumination of a surface is proportionate to the candle-power of the light divided by the distance in feet squared which separate the light from the surface; this unit is described as candle-power foot, but it may be necessary to remind you that, unless otherwise stated, it is assumed that the illuminated surface directly faces the source of light, in which case the angle of incidence is 0; at any other angle the illumination of that surface would be reduced in direct proportion to the cosine of the angle of incidence; therefore, it is necessary that, if any measurements are made on an instrument having a measuring screen which is horizontal or vertical or kept at a fixed angle, such a fact must be stated in order that the measurements may be of value. In order to avoid the necessity of making such a statement, the obvious inquiry is, why not design the instrument so that the direct illumination is always measured? My answer to this is that it requires another adjustment every time a measurement is made, thus not only complicating the design of the instrument, but also increasing the time occupied in making the tests.

It will be noticed that in the design of instrument I recommend an angle of 45° has been chosen; if it had not been for practical reasons I would have preferred a vertical screen. My reasons for abandoning the horizontal screen, which I used for many years in a type of instrument similar to that suggested by Mr. Trotter, may interest you; one reason was that the angle of incidence when measuring at a distance from the post became so large as to reduce the illumination on the screen to that point when it was difficult to get a balance, and, moreover, unless the screen was accurately leveled, considerable errors were liable to creep in; these faults made it practically impossible to measure the minimum illumination, which I consider the most important factor. For instance, at 100 feet from a post 20 feet high on which is mounted a 500 candle-power lamp the illumination on the horizontal screen used in the instrument would only amount to 0.005 candle-power feet, whereas if the screen had been illuminated by direct rays it would have been 0.045, which is nearly ten times as much, and could have been easily measured. With the instrument shown here it is equal to 0.04, and can be measured with ease and accuracy. With a vertical screen it would have been equal to 0.047, which would have been even easier to measure; but, on the other hand, it is obvious that directly under the post the vertical screen would be useless, and the illumination on the horizontal screen would be so high as to be out of the range of the instrument; this alone is one good reason for the use of this particular angle.

But there are two other reasons which I consider of equal importance; one is that, owing to the great variation in the spectrum of lamps used for street lighting purposes, a flicker method of obtaining a balance is essential for accurate work, and an angle of 45° is found more convenient in the design of this part of the apparatus; the other is that the illumination of vertical objects in a street of equal, if not greater, importance than that of the road and pavement; for instance, it is of more importance to be able to recognize faces and avoid obstructions than to be able to distinguish the quality of the road; it is true that in the case of road vehicles, particularly motor cars, the latter is of importance, but as these vehicles very generally carry lamps of higher candle-power than the street lamps, the comfort of the pedestrian is more to be considered. Therefore, by stating the value of the illumination on a screen at an angle of 45° we are probably giving the most useful information for practical purposes. Moreover, the measurements obtained at this angle are as easily converted to measurements of candle-power as would be the case if any other angle were used, and the fact that the candle-power of the lamps in one direction only is measured simplifies this calculation considerably.

There is still another factor which must be stated, and that is the height at which the measurements are made from the ground; this should be settled by the most convenient height for making the measurement, which I have found to be 4 feet.

Therefore, for the purpose of measuring and comparing the illumination of streets, roads or open spaces I would suggest that the minimum and maximum illumination, which can be derived at any point, be stated in units of candle-power feet measured on a plane surface inclined to the vertical at an angle of 45°.

Having decided a definite means by which the lighting of streets can be accurately and rapidly compared, I have, from various published statements, obtained the opinions of gas and electrical engineers as to the present day requirements in this direction, and from tests made by myself and others am able to give a rough average of what actually occurs in practice.

Birmingham.—The opinion of Mr. John Price, of Birmingham, was published in the Street (February, 1905), in which he stated that incandescent gas burners consuming 3.5 cubic feet per hour, for which he claims 42 candle-power when new, should be erected at 50 yards apart in the suburbs and 28 yards apart in the center of the city; in the very important thoroughfares two, or even three, burners may be used. This works out as follows:

Center of city, 80 candle-power at 84 feet apart, minimum direct illumination, 0.046.

Main streets, 40 candle-power at 84 feet apart, minimum direct illumination, 0.023.

Suburbs, 40 candle-power at 150 feet apart, minimum direct illumination, 0.007.

Patrick.—Mr. Maxwell, in his paper read before the Glasgow Local Section* in 1905, stated that the 12½-ampere open-type arc lamps (for which he claimed 870 mean spherical candle-power) when fixed on posts 60 to 80 yards apart in the main streets, and 100 yards apart in side streets, were satisfactory in practice. In certain instances an average distance of 110 yards apart and a maximum of 180 yards was permissible. Allowing that the candle-power of the lamps at, say 15° from the horizontal would not exceed 600, this works out as follows:

Main streets, 180 feet apart, minimum direct illumination, 0.071.

Main streets, 240 feet apart, minimum direct illumination, 0.04.

Side streets, 300 feet apart, minimum direct illumination, 0.026.

Side streets, 540 feet apart, minimum direct illumination, 0.0082.

Bradford.—The gas engineer of Bradford reports in the Street (January, 1905) that the principal streets are lighted with two incandescent gas lamps placed on both sides of the street 30 yards apart; he claims that they give an actual light of 100 candles—if this is the case, we may take it that the principal streets are illuminated as follows:

* Journal, Inst. of Elec, Engineers, vol. xxxiv , 1905, p. 729.

Two gas mantles, 100 candle-power, 90 feet apart, minimum direct illumination, 0.047.

St. Pancras.—The original 10-ampere open-type arc lamps were erected in the main streets at 330 feet apart, but even in the less important streets they are now put at 165 feet apart. The side streets were, and are in some cases, illumined with single gas mantles at 120 feet distance. I think we may take it that the modern practice will be maintained. The results are as follows, taking the candle-power of the arcs at 15 below the horizontal as 500:

Main streets (old practice), arc lamps 330 feet apart, minimum direct illumination, 0.017.

Main streets (new practice), arc lamps at 165 feet apart, minimum direct illumination, 0.07.

Side streets, incandescent gas, 120 feet apart, minimum direct illumination, 0.0095.

Croydon.—From Mr. Cramb's interesting tests embodied in a report submitted to the corporation of Croydon in July of this year, it transpired that the main streets were lighted by arc lamps giving an average candle-power of 450 at 65 yards apart, and the side streets by single incandescent gas burners, of which the best examples gave 52 candle-power fixed 80 yards apart, and by Nernst and incandescent lamps (the latter being fixed with Reason reflectors), which gave an average of 57 candle-power, and were fixed at a distance of 66 yards apart, the results being as follows:

Main streets, arcs, 450 candle-power, 195 feet apart, minimum direct illumination, 0.043.

Side streets, gas, 52 candle-power, 240 feet apart, minimum direct illumination, 0.0036.

Side streets, electric, 57 candle-power, 198 feet apart, minimum direct illumination, 0.0056.

Willesden and Barnes.—As an example of residential suburban lighting I would take Willesden, where the main streets are lighted by means of 10-ampere open-type arc lamps, 78 yards apart, and the side streets by incandescent gas burners, consuming 3.2 cubic feet of gas per hour, averaging 50 yards apart; and also Barnes, which is lighted to a large extent by ½-ampere Nernst lamps erected at 60 yards apart. The results of these two places work out as follows:

In Willesden, main streets, arcs, 234 feet apart, minimum direct illumination, 0.035.

Side streets, incandescent gas, 150 feet apart, minimum direct illumination, 0.005.

In Barnes, Nernst lamps, 180 feet apart, minimum direct illumination, 0.005.

Maidstone.—As an example of a town with a population of about 35,000, I would take Maidstone, where the High street is lighted with open-type 500-watt arc lamps at 40 to 45 yards apart; in the main streets these lamps at distances varying from 60 to 65 yards are used; and the side streets are illuminated with ½-ampere Nernst lamps at 50 yards apart. Thus we get:

High street, 500 candle-power, 130 feet apart, minimum direct illumination, 0.11.

Main streets, 500 candle-power, 190 feet apart, minimum direct illumination, 0.054.

Side streets, 40 candle-power, 150 feet apart, minimum direct illumination, 0.007.

Tonbridge.—This is a good example of a town of about 13,000 inhabitants, the lighting of which has received considerable attention of late. The High street is provided with 500-watt open-type arc lamps at an average of 90 yards apart. The residential main roads are lighted by two ¼-ampere Nernst lamps on posts erected 70 yards apart, and single ½-ampere Nernst lamps, also 70 yards apart. The other parts of the town are lighted by incandescent gas lamps, at an average distance apart of 70 yards. This works out as follows:

High street, 500 candle-power, 270 feet apart, minimum direct illumination, 0.027.

Main streets, 40 candle-power, 210 feet apart, minimum illumination (direct), 0.004.

Side streets, 30 candle-power, 210 feet apart, minimum direct illumination, 0.003.

Manchester.—From the valuable tests taken by Mr. Pearce here I have extracted the following figures, which give an example of the lighting of main thoroughfares of an important town:

Position.	Lamp.	Distance Apart.	Minimum Direct Illumination.
Piccadilly	900 watt enclosed arc.....	76 ft.	0.62
Sackville Street.....	Intensified Gas.....	58 "	0.38
Albert Street.....	600 watt enclosed arc.....	57 "	0.54
All Saints.....	Intensified Gas.....	102 "	0.14
Piccadilly.....	600 watt enclosed arc.....	66 "	0.30
Cheetham Hill Rd	Incandescent Gas.....	206 "	0.013

Gorton.—A much more interesting example in this neighborhood is Gorton, where Mr. Pearce has lately replaced 25 double Welsbach mantles, each taking 4 cubic feet of gas per hour, by 22 enclosed arc lamps giving 400 cubic candle power each. The gas lighting in this case used to cost £150 per annum; the electric lighting is done for £176. Taking an average candle power for the gas lamps based on the figures given by Mr. Price, of Birmingham, and measurements made by myself elsewhere, the candle power will work out at 80 per post; therefore, it will be seen from the following figures that the minimum illumination has been increased four times at an extra cost of 17 per cent per annum:

Old System.—Incandescent gas, 80 candle power, 90 feet apart, minimum illumination (direct), 0.037.

New System.—Enclosed arc lamps, 400 candle power, 100 feet apart, minimum illumination (direct), 0.145.

As a final example, I propose to take the much disputed City and Kingsway lighting. In the case of Kingsway, the length is 4,000 feet and the breadth 100 feet.

Kingsway.—There are 51 high-pressure gas lamps, and the measurements I had made in October averaged 670 candle power on the lamps in good condition, and 450 on those which were in poor condition. The posts are staggered, therefore, the maximum distance from any post would be 46 feet, where you would be deriving light from three sources, two of which would be available on a screen at an angle of 45 degrees, but, for the sake of comparison, I propose to consider one only. This works out as follows:

High-pressure gas, 515 candle power, 80 feet apart, minimum direct illumination, 0.206.

City, Fleet Street.—Here, as you are no doubt aware, twelve 10-ampere lamps in muranese globes have lately been replaced by thirty-four pairs of incandescent gas mantles. I have tested both of these illuminants, and am able to place before you the following figures, which require a little explanation.

In the case of the gas lamps the two mantles are placed side by side, therefore, the minimum candle power measured is across the road, where it averages 80 candle power, and this will be the point at which the minimum illumination occurs, namely, at a distance of 30 feet.

The old arc lamps were at a distance of 137 feet apart, and as they gave 680 candle power when measured at a distance of 30 feet, it can be taken for granted that 600 would be a safe average to take at the greater distance. The comparative figures would then be:

Old arc lamps, 137 feet apart, minimum direct illumination, 0.117.

New gas lamps, 48 feet apart, minimum direct illumination, 0.08.

The actual minimum illumination between the gas posts would be:

48 feet apart, minimum direct illumination, 0.18.

I think I have now stated sufficient opinions and examples to give you some idea of both the past and present practice; these very figures show the diversity of opinion, as demonstrated in practice. It is, therefore, only possible to obtain a rough average, but nevertheless this will form some basis to work on.

I do not propose to consider the more brilliantly lighted streets of Manchester, or the gas company's latest show in Aldwych and Kingsway, as there is little doubt that the illuminating of public buildings in the case of the former has been aimed at as much, if not more, than lighting the streets; and the latter case, as far as one can judge, is an advertisement for the gas companies, the cost of which will probably never be disclosed. Therefore, I think we may take it that in most towns the minimum direct illumination is as follows:

Main Thoroughfares, minimum direct illumination, 0.050 candle power feet.

Side Streets, minimum direct illumination, 0.025 candle power feet.

Suburban Streets, minimum direct illumination, 0.005 candle power feet.

These figures, I need hardly remind you, are averaged from actual measurements made in the street, and not from the fictitious values often claimed, and it is interesting to note that in many places where electric light has been installed—such as St. Pancras, Maidstone, Patrick, etc.—these values have been exceeded, whereas the actual illumination obtained from gas mantles is generally much lower than that estimated by the representatives of the gas industry.

In the case of the less populated towns it will be found that the main streets are generally on a par with what I have termed the side streets of a large city, the other streets being equivalent to the suburban streets; but in many instances, such as Tonbridge, the lamps in the less important side streets can hardly be said to illuminate them at all, owing to the long distance apart at which they are placed.

Proportioning of Street Illumination.—I have never been able to find any particular law governing the decision of the powers which settle the extent to which a street should be lighted; there is little doubt that street lighting originated in a desire to prevent crime; if this had been carried to its logical conclusion, the slums and alleys of our cities would be better lighted than the parts occupied by the more peaceful, law-abiding citizens, which is certainly not the case. It might be suggested that it is proportioned in some way by the ratable value of the houses forming the streets, but I should have thought it would have been more logical to have considered the number of people living in a street, rather than their individual wealth. The people most fitted, in my opinion, to settle the matter are the police, because upon them depends the control of the traffic, the prevention of accidents, and the reduction of crime.

And now let us see what the value of the minimum illumination is; the usual test is the possibility of reading a Bradshaw railway guide. I find, personally, that this is possible at an illumination equivalent to 0.05 candle-power foot. With 0.005 candle power foot you cannot recognize a face; in fact, can only just avoid running into anything. Mr. Trotter took for his comparison moonlight, which he found to be 0.028 candle power foot in England near full moon; thus it will be seen that in the side streets of large cities the minimum illumination approaches full moon, but in the suburban street is less than one-fifth. I would, therefore, suggest that, unless the value of illumination in any streets exceeds, say, 0.015 candle power foot, it could hardly come under the head of street lighting, but should be called "beacon lighting," as suggested by Mr. Trotter.

(To be continued.)

ELECTRICITY vs. COMPRESSED AIR FOR MINE OPERATIONS.

In recent editions of various technical journals appeared an article on "Electricity vs. Compressed Air for Mine Operations," by W. R. Hulbert, M. E. In this paper are presented in brief the advantages of electricity over compressed air for mining purposes. It is claimed that electricity is cheaper to produce, especially at altitudes, that the transmission losses are less than in an air plant; that the dangers and expenses attending the uses of compressed air are great and that electricity has the decided advantage of being serviceable for the purpose of lighting. Of course, it is well known that when two or more systems are vailable for accomplishing an end, each system has certain advantages not possible in the other. Such is the case with the electrical and compressed air systems.

Regarding the first cost or the cost of installation, the advantages are much in favor of compressed air. As far as boilers and engines are concerned each system calls for about the same investment; the equality of costs stops at this point. It is well known that the cost of installing a dynamo is greater per horsepower than for installing a compressor, and as the units decrease in size the first investment per horsepower increases, and furthermore the price of alternating current machines is in excess of that of direct current generators. If alternating current is used and has to be conveyed some distance, transformers are necessary on either end of the line; while if direct current is used a converter is needed. It is thus seen that the number of units which comprise an electrical system are great and that as the number of units increases the investment cost must correspondingly increase. The advantage is, therefore, greatly in favor of the simple compressed air system. The latter requires for its economical operation a compressor, a good pipe line and only one possible accessory in the form of a reheater. As the number of parts of a system of generation increases, the cost of maintenance and repairs increases also. Interest and depreciation likewise are important factors.

Altitude compression, due to the more rarified conditions of the atmosphere, is accompanied by a slight increase in horsepower over that necessary at sea level to produce the same results at the tool. This calls for the employment of a somewhat larger compressor. Even the additional cost of this larger machine still leaves much, as far as the costs of installation are concerned, to the advantage of a compressed air system.

Beginning with the steam engine, is it cheaper to produce electricity or compressed air for mine operations? Taking the available energy in the steam engine as unity for both systems, we find that in transforming the work into electrical current at a certain potential there is an attendant loss of about 10 per cent under good conditions; these losses are due to friction, hysteresis and magnetization. It is granted that the energy gotten out of a compressor is less than that secured from a dynamo, but the difference is slight. The losses in the compressor are due to both the friction of parts and to the thermo-dynamic requirements. The latter loss arises from the fact that compression under pure isothermal conditions is impossible. Since the jacket water cannot remove the heat generated by compression as quickly as the ideal would warrant, actual compression lies between the isothermal and the adiabatic. These losses decrease more and more as the number of stages for compressing the air is augmented. At the power station we still have the advantage in favor of compressed air, for at this point a reheater may be employed and with very slight additional cost for fuel, the energy of the air may be so materially increased as to eclipse the advantage of electricity, leaving much economy to the credit of compressed air.

Transmitting any energy necessitates losses. Electrical current flowing over a conductor must necessarily decrease in intensity as the distance from the power station becomes

greater. This drop depends directly upon the quantity of current passing through the conductor and also upon the length, diameter and quality of the wire. The energy lost in friction or resistance is expressed by

$$W=I^2 R$$

and the loss is seen to increase directly with the square of the current and directly with the length of line. Resistance varies with the length of conductor and inversely as the diameter. To diminish, therefore, the watts lost in friction, either the current or the length of line must be decreased or the area of the wire increased; the first two conditions are impossible since the machine to be operated must have a required operative current, and since the length of line depends upon the distance of the power house station from the work. The only alternative left open to us is to increase the diameter of the conductor. Those who are at all familiar with copper costs can readily appreciate the great expense that this would entail. In fact, there are instances where electrical energy is transmitted some distance under moderate voltage in which combined cost of the copper, poles and porcelain insulators was almost as great as that of the installation of the power plant proper. Of course the resistance losses due to transmission may be decreased by sending power over the line at high voltage. This calls for alternating current, that the generated energy may be transformed at the power station to a current at high potential.

Neglecting the phase relations, the pressure of a line is known to vary according to the law:

$$E=I R$$

and the energy according to the formula:

$$W=R I$$

If E and I represent the voltage and amperage at the power station, and E^1 and I^1 those at the operating station, then neglecting line losses:

$$W=EI=E^1 I^1$$

As the potential at the power station is increased, and since the products of the volts and amperes must be constant, the current must decrease. A transformer accomplishes this, giving a light current flowing at high potential attended with slight losses. These losses may be increased to reduce the copper cost by decreasing the diameter of the conductor and increasing the resistance of the line. In fact, with an alternating current we may secure with thin wire a copper loss no greater than that gotten with best conditions when employing direct current, but the use of alternating current necessitates the introduction of extra machines. We generate at the power station alternating current at normal voltage; this is raised by a "step-up" transformer which has an efficiency of about 90 to 95 per cent; the current at high potential is sent along the line with small copper losses until it reaches the place of application. At this point a "step-down" transformer must be employed with its attending losses, to bring the voltage to a safe amount for operative purposes. If the electrical tools call for direct current, as is generally the case, a rotary converter is needed to transform the current from alternating to direct. This transformation necessitates a considerable loss.

In transmitting compressed air we find different laws governing the losses. As the air flows through the pipes, the resistance of the inner surfaces must be overcome and this gives rise to a slight drop in pressure. Compressed air differs from electricity especially in that, electrical friction losses cannot be regained while corresponding losses with compressed air may be eliminated. The moderate fall in pressure in the air due to friction augments the volume of the air and does not involve a loss of transmission. "If the air were at 80 pounds gauge or 95 pounds absolute upon entering the pipe and 70 pounds gauge or 85 pounds absolute at the other end, there would be a loss of a little more than 10 per cent in absolute pressure, but at the same time there would be an increase of volume of 11 per cent to compensate for this loss of pressure and the loss of available power would be less than 3 per cent."—(See "Compressed Air Information," Saunders.)

At the point of application of the air the initial energy may be restored by adding a slight amount of heat to the air; in fact, the employment of a reheater increases the volume to such an extent that additional energy is gotten when air is used expansively at a rate of 1 horsepower per pound of coal.

In mine operations, not to interfere with the comfort and health of the men, the reheater is never pushed for all that it is worth. Compressed air is only raised in temperature slightly to make up for the transmission drop in pressure. Thus it is apparent that the loss of energy in transmitting air is nil; even when a reheater is not used the drop in pressure and the loss of energy is slight as compared with electrical transmission losses, with the advantage in favor of compressed air.

Electricity has the inherent difficulty—danger to the operator. The insulation may be defective and the effect of shock may prove fatal. Where electricity is employed for mine haulage a third rail or live wire is needed, and for apparent reasons no insulation whatever is used, the only safeguard possible are signs reading, "Danger! Don't Touch the Wires!" What guarantee from accident are mere signs? How often are live wires touched unintentionally? How great is the risk in the low headings of mines? How can printed warnings be of service to many illiterate miners, especially those of foreign birth? Furthermore, if anything should happen to the source of power the motors used on the cars or cages would stop and cause them to become inoperative; with compressed air, however, there is energy enough stored in the receivers to permit the cars being raised to the surface. The risk attending the use of electricity in a gaseous mine is obvious. Some recent mine explosions have occurred in mines supposedly non-gaseous. These facts in themselves should preclude the use of electricity in such places. Under all mining conditions compressed air is entirely safe and it may be handled by the most careless and most ignorant, with absolute confidence. Any leak in the compressed air line assists ventilation as do exhausts from all the tools; it reduces the effect of poisonous gases and dilutes or expels the smoky products of blasts.

The ventilation secured from compressed air systems installed expressly for that purpose is of itself an extremely costly process. As a matter of fact, however, no expense at all is involved in the case under discussion, as the ventilation is obtained gratis from a waste. There are instances on record where the exhaust air was of a noxious character; these were due undoubtedly to the bad practice of employing a poor lubricating oil in the compressor cylinder. Of course, such conditions should be guarded against, but they are apparently so rare as to cause no alarm.

Electricity has one advantage over compressed air. Electricity may be employed for lighting a mine, and lighting a mine with compressed air is impossible. But who needs light throughout? Few lights are necessary and those only at certain points. Were electricity employed for lighting purposes it would nevertheless be the best practice to have the lighting system independent of the power system that the lines may be intact in cases of emergency. As a matter of safety, the old form of miner's lamp has the advantage on its side. Explosions are impossible and the light is always with the operator just where needed.

Electricity has advantages which are possible with no other form of energy, but for mining purposes compressed air far surpasses it as a driving fluid. Were the cost of installation, generation and transmission of compressed air greater than that for the electrical system, the fact of the danger in employing electricity should certainly preclude its use. Compressed air stands alone in this field of operation. It is cheap, reliable, safe and effective.

The JOURNAL OF ELECTRICITY POWER AND GAS
WITH WHICH IS INCORPORATED
The Engineers' Architects' and Builders' News

Published Weekly by

The Journal of Electricity Publishing Company
701 Atlas Building, San Francisco.

Yearly subscription, $2.50. Single copies, 10 cts. Foreign subscription, $3.50 Subscriptions cannot be begun with back numbers. Manuscripts submitted must be accompanied by postage to insure return.

Address all communications and make all remittances payable to the Journal of Electricity Publishing Company.

EASTERN AGENCIES:
NEW YORK.....
CHICAGO.....
ST. LOUIS.....

WESTERN AGENCIES:
LOS ANGELES.....
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Entry changed May 1, 1906, to "The Journal of Electricity, Power and Gas," with which is incorporated "The Engineers' Architects' and Builders' News."
Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as "The Electrical Journal," July, 1895.
Entry changed to "The Journal of Electricity," September, 1895.

VOL. XVII SEPT. 8, 1906 No. 10

EDITORIAL.

THE ILLUMINATION OF CITY STREETS.

To produce the best results in city street lighting a study must be made to determine the character of illuminant as well as the system most adapted to the particular city or even the district of the city under consideration. Complete and sufficient municipal lighting under any conditions is expensive, but even in small towns, no better protection can be given to life and property than a well operated lighting system.

Upon the introduction of electricity the old flat flame gas light was very quickly replaced by the direct current open arc, and it was for the purpose of street lighting that the earliest dynamo electric machines were really developed. While the electric arc was certainly a great improvement over the gas lamp, not only in intensity but also in color, yet the light from a direct current open arc is so concentrated and confined to a comparatively small area directly under the lamp, that for uniform illumination much was yet to be desired even after the introduction of electric street lighting.

Next came the enclosed electric arc for direct current constant potential circuits, and later the enclosed alternating current lamp, also for constant potential circuits. While the so-called "normal candle power" of the enclosed type of lamp was not so great as the open arc, the resulting illumination was much more uniform, and partly for this reason, but mainly due to the smaller cost of current and attendance, the enclosed arc lamp rapidly replaced the older open arc, until at the present time, the use of the direct current open arc lamp for street lighting is very limited. It may in general be said that for municipal lighting, when electricity is used, the series enclosed alternating arc is most universally in use.

Incandescent electric street lighting, while not extensively used, has been found in many cases to give excellent results. When twenty or more one-hundred-volt 32-candle power lamps are operated in series on 2,000 to 2,400 volt circuits, the lamps being spaced 100 to 200 feet apart and fastened to the poles, the service cannot be said to be completely satisfactory, but in many recent installations where ornamental iron posts have been used, there being a total of two to ten lamps in clusters enclosed in glass globes on each support, the effect has been exceedingly good.

While the old gas lamp first used for street lighting would not be seriously considered to-day as a competitor of electricity, the Welsbach or mantle gas lamp has been recently developed so as to give most satisfactory service, the character of illumination, particularly for business, and other thickly populated districts, being quite similar to the most recently installed incandescent lighting systems.

The careful study which is being made of illumination in general at the present time is sure to result in many improvements in street lighting, whether by gas or electricity. The introduction of a unit of illumination, and photometers so constructed as to give accurate data and correct measurements of illumination rather than candle power, will also be of great assistance in determining the proper system of street lighting to install in each individual instance.

Trade Catalogues.

General Electric Bulletins.—No. 4451 gives data regarding the new Tantaluin incandescent lamp. These lamps give 22 candle power, consuming 44 watts, thus showing an efficiency of 2 watts per candle. Bulletin No. 4453, entitled "Edison 'Gem' High Efficiency Incandescent and Meridian Units," contains some very useful tables and diagrams in regard to illumination. Bulletin No. 4454 gives a general idea of the construction of G. E. 90, Form A, Railroad Motors, which is claimed to have a number of distinct advantages over other types. These motors are rated at 50 horsepower, based on a temperature rise of not more than 75 deg. C. after one hour's run at 500 volts. Bulletin No. 4455 deals with the new G. E. single-phase motor, type IS, Form K. G. These motors range in horsepower from ¼ to 15, and are constructed for both 110 and 220 volts, and for 40, 50 and 60 cycles.

H. W. Johns-Manville Co. have issued small folders, setting forth the advantages of J. M. Asbestos Roofing, the Manville Dry Powder Fire Extinguisher, and Phoenix Asbestos Stove Lining.

The Nogle Engine and Boiler Works have recently issued four interesting catalogues or bulletins descriptive of their engines and boilers. No. 43 is devoted to Corliss engines. No. 49 gives details and also specifications of different types of boilers. No. 50 gives the different sizes and capacities of boilers and high-speed engines, while No. 51 is confined to descriptions of slide valve engines.

The Central Electric Company of Chicago are sending out a circular on D. & W. Enclosed Fuses, for which they are general Western agents. This circular contains a cut of the D. & W. Fuse Company's new office and factories, said to be the most complete and largest enclosed fuse factory in the world. This circular will be sent to any address on request.

PERSONAL.

Mr. J. Lester Woodbridge, formerly engineer of the sales department of the Electric Storage Battery Company, Philadelphia, has been appointed chief engineer of that company, succeeding Mr. J. B. Entz, who has resigned to accept the position of vice-president of the Electric Vehicle Company of Hartford, Conn.

Mr. J. P. Johnston, for several years past the general sales manager for the Weber Steel Concrete Chimney Company, of Chicago, has resigned to become sales manager, Water Tube Boiler Department of the Atlas Engine Works, Indianapolis. Mr. Johnston's offices will be at the company's plant in Indianapolis.

Mr. J. F. Davis, formerly connected with the Pittsburg organization of the Atlas Engine Works, Indianapolis, has been transferred to the company's offices at Chicago.

Mr. H. R. Noach, of the Pierson-Roeding Company, has just returned from a two weeks' hunting and fishing trip through Plumas County, and reports having killed two five-point bucks, forty rattle snakes, and a million trout.

Mr. Whiteside inspected various large manufacturing industries of England and on the continent. Among them he visited the plants of the leading English steam turbine builders, whose American rights for building Parsons steam turbines for marine and land use, are enjoyed by the Allis-Chalmers Company.

Mr. A. N. Hargrove, of Philadelphia, Pa., is one of our new members of the Electrical Fraternity of the Pacific Coast. He comes to accept a position with the Pierson-Roeding Company as special representative for them of their agency of the J. G. Brill Company, of Philadelphia. Mr. Hargrove was one of the head salesmen of the home office of the above firm. Another prominent member of the electrical world who has taken a permanent position with Pierson-Roeding & Co. is Mr. M. H. Arnold, of Mansfield, Ohio, who will make a specialty of the Ohio brass company's line and railway material. Mr. Arnold comes very highly recommended as a successful young business man, and his genial personality will make him a welcome acquisition to our ranks.

Mr. H. C. Hopkins, manager of the Los Angeles office, and Mr. R. H. Husbands, manager of the Seattle office of the Pierson-Roeding Company, were in the city last week to attend the general meeting of the company's representatives.

Mr. W. H. Whiteside, president of the Allis-Chalmers Company, Milwaukee, returned on August 22nd, from a two months' combined business and pleasure tour of England, France, Germany and Switzerland.

OBITUARY.

Announcement is made of the death on August 18th of Mr. E. T. Hannam, inventor of the Atlas water tube boiler. Mr. Hannam had been connected for three years with the Atlas Engine Works, and had recently been promoted to the position of assistant manager of sales.

The Atlas Engine Works, of Indianapolis, whose Chicago sales offices have for several years past been in suites 900-902, Fisher Building, will, upon completion of the new Fisher Building, in November, increase their present rather cramped quarters by the addition of several larger offices. Mr. Frank H. Baker, connected with the Atlas for over twenty years, will continue at the head of its Chicago organization.

A UNIQUE ELECTRIC MOTOR INSTALLATION.

There are many mills, especially in New England, which depend on two sources of power for their operation, either using water under ordinary conditions, or having an auxiliary steam plant to carry the load when the water fails during the dry season. An interesting adaptation of electricity as an auxiliary motive power under these conditions is to be seen at the mills of the Joslyn Mfg. Co., South Scituate and Hope, R. I. This company operates three mills for the manufacture of shoe laces and corset strings: The Richmond mill, on the Ponogansett river; the Ponogansett mill, two miles above the first on the same stream, and the Rockland mill, situated about three-quarters of a mile west of the Ponogansett mill.

The scheme in which electricity is used to adjust the differences between steam and water is highly interesting. The idea throughout the mills is to get along without using the steam engines. The Rockland mill, located between the other two of the series, contains a small powerhouse in which is installed a waterwheel-driven, 200-kilowatt, 2,300 volt, 3-phase generator, with switchboard. The mill is driven by a 175 horsepower induction motor supplied from this generator. The steam engine with which the mill was equipped as a reserve is retained for that purpose, but will probably never be used, as at dry periods all of the available water is utilized by this mill alone, the pond near the Ponogansett mill serving as a storage basin against the droughts. The electrical equipment in the Rockland mill thus supplies power to operate that mill and assists as well to operate the other mills throughout the year.

The Richmond mill, the second mill of the three, operating 24 hours per day, ordinarily uses the water power of the Ponogansett river, but has a steam engine auxiliary for emergency. Here the electrical unit consists of a 75 kilowatt machine, which can be operated either as a generator or synchronous motor, according to the following schedule: When the plant is operated by water power this unit is belted to the line shaft and runs as a generator in multiple with the 200 kilowatt generator at the Rockland mill, taking its share of the load. When the water is low the unit is used as a motor, drawing current over the transmission lines from the Rockland mill generator. The Richmond mill engine is therefore seldom if ever used.

At the third mill, the Ponogansett, there is a 10-hour working day, and water power is depended upon entirely for operating the machinery. In this mill a 60 horsepower motor is used to drive the line shafting, while a 100 kilowatt synchronous unit operates either as a motor or generator in a similar way as in the Richmond mill.

Both the Richmond and the Ponogansett mills are lighted by electricity, taking current through transformers from the transmission line.

In addition to this ingenious method of obtaining the most economical operation, the installation is further noteworthy because of the use of high voltage motors within the mills. The transmission line enters each mill in rubber insulated, lead covered cables, laid in galvanized iron loricated conduit with the sheath grounded. The motor frames are likewise connected to earth so that all danger of fire or shock is eliminated. The electrical equipment, including induction motors, synchronous motors (or generators, as the case may be) and exciters, as well as the switchboards, was furnished by the General Electric Company.

John A. Roeblings Sons Co. announce that they are now occupying their new offices at 202 and 204 Second street, between Howard and Folsom. Phone Temporary 1369.

SOME FUNDAMENTAL CHARACTERISTICS OF MERCURY VAPOR APPARATUS.

By Percy H. Thomas.

Introductory.

The characteristic of the type of mercury vacuum apparatus, invented and developed by Mr. Peter Cooper Hewitt, which distinguishes it most clearly from other forms of vacuum tubes, is its power of passing a comparatively large continuous current with a constant and comparatively insignificant voltage loss. There are, of course, other important features of this mercury vapor apparatus characteristic to it, such as the negative electrode starting resistance; the disintegrating, reconstructing negative electrode, etc.

It is the object of the present paper to discuss a number of the more prominent fundamental characteristics of mercury vapor apparatus, and their reactions on the related electric circuits; and further to suggest a conception of the nature of these phenomena which shall be consistent with the latest theory of electricity. A certain amount of repetition of information already published will be unavoidable.

Electrical Characteristics of the Current Path in the Vacuum.

Current passing through the vacuum space in the mercury vapor appartus experiences a loss of voltage, the numerical value of which tends to remain constant independent of the current strength, except with small currents; for example, currents less than one or two amperes. Although this voltage loss, or drop, is practically independent of the current strength, it still is not of the nature of the counter electromotive force of a storage battery or motor, which latter are capable of delivering current in a reverse direction on the removal of the supply electromotive force. Neither is it equivalent to an ohmic resistance, for it is of an entirely different nature. It cannot be properly spoken of as a resistance at all; it is a voltage loss.

This loss is the sum of three other losses, more or less different in character; that is, the vapor loss, the positive electrode loss, and negative electrode losses.

Vapor.—1. The voltage loss in the vapor increases with increase of vapor pressure, and more or less closely in proportion to this pressure; consequently, since the mercury vapor is saturated and its pressure depends directly upon the temperature of the mercury electrode, the vapor voltage loss is more or less proportional also to the temperature of the mercury electrode or electrodes.

2. The voltage loss depends upon the chemical composition of the vapor; that is, it will be different with oxygen, hydrogen, and air, even at the same pressure; and all of these give a much greater loss than mercury, which is one of the great advantages in the use of the latter.

3. The voltage loss is directly proportional to the length of the vapor.

4. The voltage loss is inversely proportional to the diameter of the vapor path, but not, as might be supposed, inversely as the area of the path.

5. The voltage loss is nearly independent of the current strength, but varies slightly in a direction opposite to the current.

Positive Electrode.—The loss of voltage which occurs at the positive electrode is practically independent of the current strength. The energy represented by this voltage appears as heat at the surface of the electrode. The material of the solid positive electrode seems to have no appreciable direct effect on the volts lost, but a mercury positive, except when perfectly cold, has a loss some volts higher than the solid, probably because of a layer of comparatively dense vapor produced at its surface by the current. This is usually to the disadvantage of the mercury electrode. As the watts energy liberated in the form of heat at the positive electrodes in a commercial apparatus may be quite considerable, the solid positive electrodes have a further advantage over mercury in that they will become heated during operation, and radiate a considerable portion of the heat developed on them, as heat is radiated from a hot coal. This puts no burden on the cooling power of the bulb itself, while mercury positive electrodes will be kept cool by the evaporation of the mercury and additional vapor must be condensed by the bulb. The voltage loss on the positive electrodes is usually found to vary a good deal, but not on account of current variation. Its minimum value is about five volts. Apparently on account of an accumulation at this electrode of a certain amount of some foreign gas, such as air, which has already been stated to have a higher resistance than mercury vapor, the positive electrode loss appears often more than five volts. The loss is practically independent of the temperature of a solid positive electrode.

Negative Electrode.—During normal operation there is also a voltage loss at the negative electrode, practically independent of the current. In a mercury electrode this loss is probably about four volts. It is practically independent of temperature and physical form.

This loss of voltage during operation must be distinguished from the resistance to starting, residing at the negative electrode and usually called the negative electrode starting resistance, or, more briefly, the negative electrode resistance.

The current enters the negative electrode through a very clearly defined small, bright area, or "spot," even on very large electrodes, which normally flits about rapidly over the whole surface when not subjected to the influence of a magnetic field. When, however, a magnet is brought into the neighborhood, the electrode spot is driven to one side as far as the edge of the electrode. By providing an amalgamated metallic body at the surface of the electrode, the negative electrode spot may be caused, under some conditions, to rest quietly on the surface at the junction of the mercury and the solid material.

The negative electrode spot causes a violent agitation on the surface of the mercury and acts as though it exerted a pressure downward, making a depression on the surface. There is, at the same time, a very rapid evaporation of mercury at this point, which seems to be an essential part of the transfer of the current from the vacuum space to the electrode proper. At the same time that the negative spot is vaporizing mercury, it is also heating the electrode itself, which finally becomes so hot as to cause further vaporization. The evaporated mercury is cooled and condensed by contact with the bulb, on the inside of which it collects in drops. The drops grow larger and finally run down into the electrode, tending to cool it.

Thus by the passage of current, the negative electrode is heated and mercury evaporated—and further, the vapor itself and the positive electrode are heated. Since the coolest surface in contact with the vapor is the bulb, the vapor condenses on its surface, so that the heat which was abstracted from the mercury electrode by evaporation is delivered to the bulb by condensation. There is in addition some heat radiated directly from the positive electrode when this is of solid material. As there is a best pressure for the mercury vapor in the operation of the apparatus, it is evident that there must be a definite relation between the heat generated and the heat radiated or dissipated by the bulb. In mercury vapor lamps this fact leads to the use of the so-called "condensing chamber," for the light-giving tube alone has not, in the sizes used in practice, sufficient cooling surface, and, furthermore, it is preferable that the condensation shall not occur where it can obstruct the passage of light. In converters the main object is to get as much cooling surface as possible with the shortest practicable vapor path.

The operating negative electrode when the current does not exceed three or four amperes, and the temperature is comparatively low, has a remarkable characteristic in that it

experiences at irregular intervals an extremely sudden and abrupt return of the negative electrode starting resistance. This may occur in any degree of severity and at any instant. The tendency, however, lasts but for the briefest instant of time, and has little or no effect on an ammeter measuring the current in the apparatus. As could be expected in view of this behavior, it is desirable to provide a mercury vapor apparatus using small currents, such for example as the 3.5-ampere lamp, with special means for overpowering this momentary increase of resistance. The well known choke-coil (properly called a sustaining coil) used in connection with Mr. Hewitt's lamps, serves this purpose. It is evident that when once the current has been established in the coil, any action tending to stop the current is resisted by the energy stored in the coil, so that by making the coil large enough, this resistance, which exists only the briefest instant of time, will be entirely overcome. This tendency practically disappears with currents over four or five amperes, and also when the negative electrode is very hot. It is most severe on a cold negative and on a small current. With one ampere on a cold negative it is very difficult to secure steady operation of the negative electrode. This tendency is, to a certain extent, cumulative; that is to say, a certain choke-coil will run the lamp a few seconds, a large coil a few minutes, a still larger coil an hour, while perhaps a still larger coil will be necessary for continuous operation. It occurs absolute'y independently of any variation in the supply voltage.

Its most unexpected feature is its extreme abruptness, probably at least of the order of one one-hundred-thousandth part of a second. Of course, only choke-coils with open magnetic circuits can respond quickly enough to be of service in counteracting this impulse. As a natural result of the extreme abruptness of this action, it has been found that even a very slight electrostatic capacity, such as the capacity between a twisted pair of insulated wires ten feet long, has a great weakening action on the coil if connected between it and the negative electrode. This result seems out of proportion to the value of the energy stored in the capacity to the energy stored in the choke-coil. Presumably the brief instant required for the instantaneous charging of this small capacity which must be accomplished before the choke-coil can supply voltage to the electrode, is sufficient to allow the negative electrode resistance to be established.

Starting Characteristics.

A voltage considerably higher than the normal operating voltage may be required for starting the flow of current through the vacuum. For a tube of definite diameter the difference between the starting and the operating voltages is very small for short lengths of tube, perhaps up to ten diameters. But the operating voltage increases directly as the length, while the starting voltage increases more nearly as the third power of the length, so that for long tubes there is a very considerable increase of voltage required for starting. On the other hand, the starting voltage is lessened by increasing the diameter of the tube. This high starting voltage is partly due to the necessity of establishing a path through the opposing gas, and to vapor molecules initially filling the whole space. Once such a path has been established with a considerable volume of current, a much less voltage will evidently keep it clear. In many types of apparatus it is found convenient to start on an auxiliary positive electrode placed near the negative and transfer the current to the main positive electrode after starting. In this case the starting resistance of the vapor path to the main positive electrode must be overcome before normal operation can be established. In a converter bulb where the distance between the negative and the positive electrodes is comparatively short, no greatly increased voltage is required for starting the current through the vapor path proper. In a lamp tube 45 inches long and 1 inch in diameter, such as is used in one type of commercial lamp, several times the operating voltage may be required for starting the current through the vapor, independent of the negative electrode starting resistance. A high resistance filament connected to the positive electrode and extending into the neighborhood of the negative will reduce this vapor starting resistance by allowing the current to climb up, so to speak.

Positive Electrode.—There appears to be no resistance to starting at the positive electrode other than the normal operating resistance.

Negative Electrode.—The negative electrode starting resistance is too well known to need further description. There are two well known methods of overcoming this starting resistance:

1. By establishing a current through a complete metallic circuit within the vacuum, and breaking this circuit within the vacuum, in which case the original current will continue to flow, since the negative electrode resistance never has a chance to assert itself. This result may be accomplished by having two mercury electrodes which may be brought into contact by tilting the container, or otherwise, or by moving suitable parts from outside by a magnet. This type of starting is one of the most commonly used at the present time.

2. The second method of starting consists in directly applying a high potential with or without the addition of various means for reducing the starting resistance.

This negative electrode starting resistance is a very variable quantity, and ranges from almost nothing to many thousand volts, according to conditions. It is very much greater with a cold electrode, especially a cold mercury electrode. It is dependent upon the form and surroundings of such an electrode, and especially upon the potential or charges on the outside and inside of the insulating walls which confine the electrode. If the negative electrode is provided with a metallic strip, called a starting band, outside the container, and this strip be charged at a potential different from the electrode, the starting resistance is weakened or may be entirely overcome. On the other hand if this band or strip be connected to the negative electrode itself, the negative electrode resistance is rendered more stable since it is protected from charges. This is the principle made use of by Mr. Hewitt in starting some of his lamps, and has been already fully described by him. The interruption of the current in the quick-break switch causes a momentary high potential impulse from the choke-coil, which is applied, both to the starting band in the neighborhood of the negative electrode and to the main positive electrode. The former serves to break down the starting resistance of the negative electrode, and the latter supplies the starting voltage for the vapor path. In this method of starting, a small spark or series of sparks can be seen jumping from the edge of the negative electrode to the inside surface of the glass opposite to the starting band, which surface forms the inside coating of a small condenser, the starting band being the outside coating. This small spark is undoubtedly what overcomes the negative electrode resistance.

Physical Nature of Vapor Conduction.

It is interesting to speculate as to the nature of the phenomena connected with mercury vapor apparatus, and to endeavor to discover some assumption upon which they can be explained, which shall also be consistent with the best hypothesis as to the nature of electricity. The writer has gradually arrived at a way of looking at these things which explains nearly all of them quite satisfactorily, and it is here described for what it may be worth, with the distinct understanding that it is merely a tentative theory until a sufficiently complete body of information shall be available to prove or disprove it.

We may assume that by electricity is meant a greater or less number of those small particles, described by J. J. Thompson as having a mass of about one one-thousandth part of the hydrogen atom, called electrons. A cur-

rent of electricity, then, is nothing but a stream of these electrons. Since they move in a direction opposite to the conventional current direction, they are said to carry a negative charge; whether the electrons are electricity or carry charges of electricty is immaterial in this case. When we have a direct current passing through mercury vapor apparatus, we have a continuous stream of electrons passing from the negative to the positive electrode within the vacuum and returning through the external circuit, which must include a source of electromotive force. These electrons are caused to move by the electromotive force of the circuit, which causes an increase of potential (that is, a deficiency of electrons) at the positive and a decrease of potential (that is, a surplus of electrons) at the negative; or, to put it another way, a static charge is produced on the positive electrode which attracts the electrons, while they are, of course, repelled from a negative charge on the negative electrode. The moving electron, like a moving electric charge, stores energy electromagnetically; that is, has inertia.

These electrons are invisible of themselves and pass with extreme velocity, naturally in straight lines and where unrestrained tend to spread apart and fill the whole vapor path.

In a mercury vapor apparatus the voltage loss in the vapor itself is supposed to be due largely to the presence of molecules or atoms of gas in the path of the electrons which impede their free motion. Since the greater the number of gas molecules in a given space the greater the pressure, it is natural to suppose that increase of pressure would mean increase of resistance to the electrons. Furthermore, these gas atoms or molecules are agitated and set in vibration in being struck by electrons and are caused to give off both light and heat. The light naturally will be the spectrum light of these particular atoms; that is, the particular color or colors corresponding to the natural period of vibration of this particular kind of atom.

When the pressure is sufficiently high, the electrons, instead of spreading through the whole space, are forced into a narrow stream in the center, and the obstructing molecules are at least partly forced to the outside, to be spectators as it were. This effect can be very easily seen by heating the condensing chamber of a mercury vapor lamp with a flame until the vapor reaches a comparatively high pressure, the current will then "string"; that is, will be confined to a brilliant, thin, sinuous line near the center of the tube.

The varying specific resistance of different gases is easily explained by the differences in the character of the molecules.

The negative electrode is assumed to be the source of the electrons which enter the vapor, and the phenomenon of the negative electrode starting resistance is easily explained; that is, if we imagine the small electrons to be material particles, a considerable force would be required to cause them to break out from inside the liquid mercury surface on account of its surface tension, while when once the flow is established on a large current, it is easy to imagine that either on account of the extreme local heating at the surface of the negative electrode, or the rapid evaporation of mercury into vapor at the negative spot, there should be no opportunity for the formation of a new surface on the mercury which could re-establish the electrode resistance. On the other hand, with small currents it is found that the surface tension is able to re-establish itself in spite of the current, so that with currents of intermediate values it would be expected that at intervals the mercury would be able to re-establish the normal surface when accidentally the conditions should be favorable. Hence the advantage of employing a sustaining coil in connection with apparatus using small currents. The lessening of the negative electrode starting resistance, and the lessening of the importance of the sustaining coil with the heating of the electrode correspond properly with the corresponding reduction in surface tension.

The normal operating voltage loss at the negative must be connected with the separation of the electron from the mercury atom and the evaporation of mercury.

According to the assumption, it should be noticed that the source of electrons is not the ionization of the gas or vapor within the container as in many other experiments—such as the passing of current through air ionized by X-rays—but is the negative electrode itself; that is, within the vapor space during the flow of current we should find normally no positive ions (which are to be taken as atoms or groups of atoms which have been deprived of one or more electrons), only the electrons drawn out of the negative electrode. Thus it would be possible to pass current through the apparatus, even were it to have a perfect vacuum within. Although the resistance to starting in an apparatus in this condition is very high on account of the extreme surface tension, and on account of the absence of positive ions (as more fully explained in a later paragraph), yet once the apparatus is started, the passage of current is exceptionally easy and no light is obtained. It is actually found that with cold mercury electrodes no light appears with current of over 100 amperes. This is a very interesting point, as it has commonly been supposed that a perfect vacuum is a non-conductor; whereas the truth probably is merely that a perfect vacuum has an extremely high starting resistance, but is a most perfect conductor once current has been established.

The question naturally arises: why the negative electrode resistance does not exist in connection with arcs between electrodes in air at atmospheric pressure? It is possible that the following is the proper explanation: the application of a sufficiently high potential previous to the breaking down of the gap upon a spark-gap in air causes an ionization of the air between the electrodes, the negative electrons being attracted to the positive electrode, and the positive ions to the negative electrode. The negative electrons, of course, enter the positive electrode without difficulty, while the positive ions are stopped at the surface of the negative electrode on account of the negative electrode resistance, and attract electrons from within the metal of this electrode up to the surface. We then have positive and negative charges attracting each other, and separated merely by the surface of this electrode, which causes a tremendous strain and is sufficient to withdraw electrons from the negative electrode to neutralize the positive ions, thus breaking down the negative electrode resistance. According to this theory (there being no ionization of vapor), no positive ions will be formed in the mercury vapor apparatus and no such strain produced on the negative electrode; in other words, the vacuum causes the withdrawal of the positive charge (which tends to start the negative) from the surface of the negative as in the air to the positive electrode with a vacuum; thus very much reducing the strain produced on the negative. Hence, the mercury vapor acts as though it could not be ionized in the same sense as oxygen or nitrogen, which is more or less natural in view of the monatomic nature of mercury vapor, especially at vacuum pressures. This theory beautifully explains the "softening" of X-ray tubes by the production within the vacuum space of a slight amount of gas, which becoming ionized renders the cathode more easily broken down.

X-ray tubes, Crooke's tubes, and similar vacuum apparatus cannot operate as the vapor electric apparatus of Mr. Hewitt, for two reasons:

1. Because they are not operated with a supply capable of furnishing enough energy to break down completely the negative electrode resistance and reduce it to a normal running value; and 2, because they are so physically constituted as to destroy themselves if operated with supply apparatus of sufficient energy for operating Cooper Hewitt apparatus.

It should be noted that within the vacuum space of a mercury vapor apparatus are two streams of material; electrons passing from the negative to the positive electrode, and the atoms of mercury vapor passing from the negative

electrode spot and other hot mercury surfaces to the cooler parts of the container, where they condense. Both of these streams of particles, though so radically different in character, have the power of sweeping with them atoms and molecules of any gas which may be found within the vacuum space, i. e., any such residual gas tends to collect at the positive electrode, or at the condensing surface of the retainer. In the latter location it is very readily absorbed by the condensing mercury, which explains the fact that some apparatus, originally in slightly imperfect condition, will improve with actual operation. At the positive electrode, however, if sufficient in quantity, this accumulated gas will usually raise the voltage of the apparatus on account of its intrinsically high specific resistance, and may also cause an excessive heating of the electrode.

On account of the general acceptance of the hypothesis that electricity is constituted of or connected with electrons which pass from the negative electrode to the positive electrode in the vapor path, it has been proposed to reverse the convention as to direction of the electric current adopted long ago, before any marked difference between positive and negative had been discovered; viz., the convention that current runs from the carbon to the zinc element of a battery in the external circuit.

We then should say that a positive current is one which passes from the mercury electrode of a vapor lamp to the iron electrode, and an electron would carry a positive charge or be a positive charge according to the particular assumption as to the nature of electricity which might be accepted. Such a change would certainly be highly desirable, except for the great probability of confusion for some time afterwards.

Mercury Vapor Lamp.

As a lamp, the mercury vapor apparatus has a number of interesting characteristics. Its great efficiency, which in long tubes reaches one-third watt per candle power (exclusive of resistance losses), is obtained only when run under the most favorable conditions; for example, only with the proper vapor pressure, current, and tube diameter. Mercury vapor is a much more efficient material for light production than most other gases and vapors whether used alone or mixed. The addition of atmospheric air, for example, to mercury vapor, even in very small quantities, increases the voltage on the tube very much, thus increasing the energy supplied.

The spectrum of mercury vapor is, furthermore, one of the most complete and usable gas spectra; it contains a variety of colors in substantially equal proportions, chiefly an orange-yellow, a yellow, a blue and a violet, with a smaller amount of a green-blue. The only portion of the spectrum not pretty well represented is the red, which, generally speaking, is the least desirable color. The mercury spectrum has proved to be excellent physiologically, and extremely well adapted to most mechanical processes. It is possible, of course, by the addition of other gases to add red to the spectrum, which may then be quite prominent, especially if means are taken to condense a portion of the mercury vapor. In general, however, these combinations of gases are more or less likely to deterioration and alteration, and have a considerably lower efficiency than pure mercury vapor. For most purposes the color would not be more desirable with the addition of red.

Light Efficiency.—The efficiency of mercury vapor as a source of light follows a number of laws. 1, the watts per candle power vary with the pressure of the vapor, having a minimum at a certain pressure. 2, it is nearly independent of the current strength within certain limits, in this case it being assumed that the pressure, temperature, etc., are constant. 3, superheating the tube, and consequently that portion of the vapor emitting light, seems to have little effect.

It can be shown by the normal lamp voltage characteristic curve that the relation between the current and voltage of the operating lamp, that the most efficient light giving point is at, or nearly at, the point of lowest voltage on this characteristic. This is fortunate, since for purposes of regulation this is a most desirable point to operate the lamp. Above this most efficient point the pressure of the mercury vapor increases rapidly, and while also increasing the candle power it increases the voltage in the tube in still higher proportion. Below this point the voltage on the lamp rises, probably partly on account of traces of residual gas not exhausted in the pumping, which causes a great dropping off of the quantity of light and the efficiency. These residual gases are here more prominent on account of the lower mercury temperature and vapor pressure.

It is evident that the temperature of the mercury electrode and the pressure of the mercury vapor resulting from a given current will depend directly upon the air temperature surrounding the lamp. In the commercial types of lamp, however, the actual change in efficiency from change in atmospheric temperature is very slight throughout the practical working range.

Lamps may be made for various uses with different diameters of light-giving tubes. The diameter most commonly used and suited to 3.5 amperes is 1 inch, or a trifle less, in inside diameter. To give the same intrinsic intensity with other diameters the current should be varied in proportion to the cross section of the tube; that is, for a 2-inch tube we should require about 14 amperes. Since the voltage decreases as the diameter of the tube, and since at the same intrinsic brilliancy the quantity of light increases as the diameter on account of the larger surface, we should expect double the light and double the energy consumed with the larger tube. It is found by measurement, however, that the larger tubes are somewhat more efficient, so that there is a saving of 20 to 25 per cent on the efficiency for 2-inch over that of 1-inch tubes—inversely with smaller tubes and the appropriate currents. With smaller tubes, however, the difficulty of maintaining the negative alive becomes very much greater on account of the small current which, as already explained, is subject to momentary impulses tending to stop the flow of current.

There can be no one proper method of measuring the candle power of a Cooper Hewitt lamp; first, on account of the fact that the color of the lamp is different from the color of any accepted standard, and because it is a spectral against a continuous spectrum; and secondly, because the light-giving tube is not a point, and the law of inverse squares does not hold except at very great distances. For commercial tests the candle power of the lamp should not be measured at a great distance, since the lamp has a practical advantage over advantage it would lose were the candle power measured at a considerable distance. Where it is important actually to define the candle power of these lamps, the particular method of measurement to be used must be specified.

Alternating-Current Lamp.—The principle of the alternating-current lamp is generally well understood by this time. It is evident that during one alternation, current is supplied from one-half of the transformer secondary through the lamp tube back to the neutral point, and during the other alternation by the other half of the transformer secondary through the tube to the same point, and that the choke-coil in the negative lags the current over the zero points.

The light from the alternating-current lamp is practically equivalent to that from the direct current, since in the light-giving portion of the tube the light is substantially direct current.

On 25 cycles, by providing a larger choke-coil in the negative than is necessary in the 60-cycle lamp, the natural tendency to flicker with the period of the 25 cycles is eliminated.

Starting.—The method of starting in the type-C alternating-current lamp is an extension of that of the direct-current lamp and is of some interest. A small electrode or pin is

placed in the head of the lamp, and connected to one of the positives through a rather high ohmic resistance. In starting, the lamp is tilted so that the mercury forms a continuous stream from the negative to the positive end, and is carried by its momentum up around the inside end of the tube until it touches the pin which is placed on the top side of the tube. On account of the irregularity of the flow of the mercury it here makes and breaks contact with the pin a number of times, each time causing a breakdown of the negative electrode resistance, either on the column of mercury or the pin. In the latter case the lamp will go out at the end of the alternation. If, however, the mechanical break at the pin occurs during such an alternation that the mercury column is the negative, the lamp will start to operate upon the pin, and that main positive electrode to which the pin is not connected as positive electrodes and the mercury stream as the negative. Then, on account of the starting resistance connected with the pin, the current will be immediately transferred from it to the corresponding positive, and the lamp is started. The lamp is then returned to its normal position and all the mercury flows back to the negative. If, now, there were no resistance between the pin and its positive electrode, and assuming the lamp to have been started during tilting by one of the breaks between the mercury and the pin, it is evident that if the mercury touches the pin again, that the lamp will go out, since for this instant the flow of current does not enter the vapor at all (on account of the metallic connection between negative and one positive). That is to say, if it were not for this resistance which prevents current when once transferred to both main positives from being withdrawn by a subsequent connection between the mercury and the pin, the lamp would be started and put out and started again repeatedly. Only the last break between the mercury and the pin would count in starting, and we should fail to light the lamp more often than we succeed. As an actual matter of fact, lamps have been built which started practically every tilt, though the average commercial lamp is not expected always to light at the first trial.

Mercury Vapor Converter.

The Cooper Hewitt apparatus may, as is well known, be utilized to supply direct current from an alternating current supply by virtue of the negative electrode resistance. No further description of the general method of accomplishing this result is necessary at this time. The converter may be run single phase, in which case a connection similar to that already described, except for starting circuits, is generally used, though it may be three-phase, four-phase, etc., in which case no choke-coil in the direct-current circuit is usually required.

Starting—In a converter a very short vapor path is purposely provided, and the starting is easily accomplished by breaking a metal circuit in the vacuum as already described, for the current is here easily transferred from the starting to the main positive electrode. The method can be easily seen from Fig. 5, which shows a form of commercial bulb used for a single-phase converter together with starting circuits. There are two electrodes of mercury, one being the main negative and the other a starting electrode. By shaking these two together, passing current through and separating them, the negative electrode resistance is broken down and the voltage upon the main positive electrodes forces current to flow to the main negative. The supplementary positive should then be cut out of the circuit. Converters, however, can be started by starting-band and high-tension impulse, or by the direct application of sufficiently high potential.

In cases where the converter is to feed a storage battery, it will be noted that the electrical connection for the alternating current lamp is not perfectly satisfactory, on account of the comparatively large direct current sent by the battery through the transformer winding when the negative and starting electrodes are connected, which is in the wrong direction to start the negative electrode as a negative. The high impedance of the sustaining coil prevents any considerable alternating current from flowing, but does not seriously limit the flow of direct current from the battery, which thus tends to make the starting positive a negative. The difficulty may be avoided by causing the battery to start the supplementary electrode as a negative, whereupon the main positives start operation with the supplementary as a negative, passing current through both the resistance and the battery, through a small shunt coil. If, then, a second connection is made between the starting and the main negative electrode, the current is shunted from this coil through the main negative, and on the second separation the main negative starts in the proper direction, as current is now passing against the battery instead of from it. On account of the liquid character of the mercury, it is found by experience that with one tilting operation two "makes" and "breaks" are ordinarily produced between the main and starting electrode, so that the initial starting on the supplementary electrode and the transfer to the main negative occur almost together so as not to be distinguishable by the eye. The starting circuit should usually be cut out during regular operation. By making the shunt coil a magnet for tilting the bulb, the starting is automatic. This method has an advantage over other apparatus for automatic starting in that it is not necessary to operate any switches in the main circuit carrying the heavy current; the only cut-out that is necessary is the disconnection of the starting circuit which carries at most one or two amperes.

Converter Bulbs—There are very few new fundamental features or conditions introduced into the mercury vapor apparatus in its use as a converter. One characteristic, however, deserves mention; there is a tendency, under certain conditions, for the negative electrode resistance of a positive electrode to fail, which causes current to flow from some other positive directly to the positive in question, causing practically a direct short-circuit on the system. By proper design this tendency can be controlled very effectively.

The chief feature of interest of the converter is in the new electrical relation introduced into the receiving and supply circuits by the introduction of the converter. Before discussing this relation, however, it will be well to say a few words on the bulb itself. The heat represented by the 14 volts lost in the vacuum, times the current actually flowing, must be dissipated by the bulb. Artificial cooling means may be used, such as fans, immersion in oil, water, etc. Furthermore, a certain portion of this heat is dissipated as radiant energy from the positive electrodes, when these are made of solid material.

Although it is possible to operate converter bulbs, utilizing as seals for introducing current one or more platinum wires of the general character of those used for seals in commercial types of lamps, still it is highly desirable on currents over 20 to 25 amperes to have seals for entering the current to the bulb which shall be able to carry momentarily a great deal more current without cracking the glass. Such a seal has been devised by forming platinum into a cup-shaped piece, having a threaded boss on both the inside and the outside of the bottom of the cup. The glass is sealed to the outer edge of the cup, and the electrode stem and external lead respectively are connected to the two threaded bosses. In this form of seal the current does not pass through the metal which is directly sealed to the glass, so that the glass-platinum joint is heated only by heat conduction.

Parallel Running—Vapor converters can be run in parallel under proper conditions without difficulty. The general condition determining satisfactory paralleling is that the voltage absorbed in each of the paralleled circuits shall increase at least slightly with increase in current, since this insures a division of current between the two circuits. If two devices be used in parallel of such a nature that with increase in current a less voltage is absorbed, such as most mercury vapor

lamps, it is evident that the more current one of these devices takes, the more current it tends to take in proportion to the other device on account of its lowered voltage. The bulb of a vapor converter also is usually a device of this character; that is, an increase in current, the temperature remaining constant, causes a decrease in voltage throughout the operating range. In such cases they cannot be connected in parallel directly, since one bulb or the other would instantly take all the current. By the insertion somewhere in the paralleled circuits of a sufficient amount of ohmic or inductive resistance, so that the additional voltage absorbed in the resistance on any increase in current shall be greater than the decrease in voltage in the bulb, satisfactory parallel operation is obtained. Since the voltage change on the bulb would not ordinarily be more than a volt or two, a very slight amount of resistance is sufficient to insure good operation. Obviously, inductance may be substituted for resistance in such parts of the paralleled circuits as carry alternating or intermittent currents.

Since small currents usually require the stored energy of a sustaining coil to maintain them in operation in a converter as well as in a lamp, if a single sustaining coil be placed in the portion of the circuit common to two bulbs connected in parallel, the impulse of the coil, which would otherwise maintain either negative electrode in operation at the time of the momentary tendency to drop out, will be discharged through the other bulb as the easier path, and the first converter will drop out. Consequently, for such types of apparatus it is desirable that each bulb have its own sustaining coil included in the part of the circuit belonging to this bulb alone.

The sustaining coil has the function of supplying energy at low voltage during the zero points of the electromotive force. If one sustaining coil be utilized for two or more bulbs under conditions in which energy is not required for resisting the instantaneous impulses of the negative electrode, it must provide energy for both bulbs. Fortunately, if the coil is powerful enough the energy will be delivered to both bulbs, provided the two circuits are so arranged with resistances or otherwise as to operate in parallel on the generator.

Since a somewhat increased voltage is required in the bulb in starting, to overcome the vapor starting voltage, it is ordinarily more difficult to start one of a number of bulbs connected in parallel after another has been started. For the voltage which is normally lost during running in resistance in other parts of the circuits, is available in a bulb operating singly as an excess starting voltage, while with one of a number of paralleled bulbs operating, since the voltage between the alternating-current and direct-current sides of the other bulbs has been brought to the operating value by the first bulb started, this excess voltage is not available for starting the second bulb.

A number of bulbs designed to operate in parallel can be arranged automatically to cut themselves in and out, either according to the load, or by the accidental dropping out of one of the several bulbs in operation. For this purpose the automatic tilting and starting arrangements used with single bulbs can be controlled by series magnets in the load circuit or in the individual bulb circuits.

Ratio—The "ratio" of a vapor converter is a rather uncertain term, but may be determined in any given cases as follows:

Any single-phase vapor converter operated from a three-wire source, or a transformer with a middle point, is practically equivalent, as far as the direct-current circuit is concerned, to the application of the original alternating-current to the direct-current circuit (including the sustaining coil) with the negative supply alternations reversed. This gives a pulsating voltage, the pulsations being of sine form and running to zero for one instant twice every cycle. The choke-coil smooths out the current pulsations more or less according to its power and the character of the direct-current load. The smoothing action is much greater with a load of ohmic resistance than with a storage battery or motor or other consumption device having a constant potential feature. The direct-current voltage is measured ordinarily by a direct-current voltmeter which gives the average reading, not the effective reading, of the pulsating voltage, while the alternating-current voltage is measured by an alternating current voltmeter which measures effective values; so that the direct-current instrument will show a reading on the same voltage of approximately nine-tenths that of the alternating-current instrument. This difference appears in the ratio of the vapor converter. Since only one-half of the voltage across the positives is operative at any one time, we have in addition the factor ½ between the voltage across the positives and that in the direct current supply, so that the voltage on the direct-current side, measured by direct current voltmeter, will be 0.45 of the voltage across the positives in the condition assumed. In this case the voltage on the bulb and all auxiliary losses must be included in the direct-current load. If an alternating-current instrument be used for measuring the direct-current voltage a somewhat higher ratio (0.50 as a maximum) may be obtained, according to the degree of smoothing accomplished in the choke-coil. The smoother the direct current the lower the ratio. Both alternating-current and direct-current instruments will, of course, read the same on a perfectly steady current, such as would result from an infinitely powerful sustaining coil. A wattmeter on a vapor converter, having a resistance load, will show a power-factor less than unity, under most conditions, and yet there is no lag between the zero point of the current and the zero electromotive force of the supply. This condition results from a distortion of the current wave resulting from the action of the sustaining coil in the direct-current circuit. The power-factor appears less than unity, since the distortion of the current is equivalent to the addition of higher harmonics which being of a different periodicity from the supply can deliver no real energy while still increasing the effective value of the current. These matters are of great interest and practical importance, but would require too much space for further discussion in this paper.

The ratio of the current in the direct-current load to that in the supply circuit is one-half, except for the variations of instrument indications which result from wave-form distortion, and except for the fact that a certain amount of current is supplied to the load by the sustaining coil at periods of low supply electromotive force which current does not appear in the supply. It is here assumed that the supply is connected directly across the positives.

Current Control—Where a direct current of constant potential is desired through the use of a vapor converter, this can be properly accomplished by the direct connection of the work circuit through the converter and a sustaining coil, and the constancy of the direct current potential will be directly equal to that of the alternating-current supply, since though 15 volts are absorbed by the bulb this value does not increase with increase of current.

In cases where it is desired that the direct-current potential shall be continuous, even when no direct current is drawn, it is evident that with single-phase converters auxiliary means must be supplied to keep the bulb in operation. This is accomplished in a number of ways, for instance, by a shunt which is kept always running, or by providing a separate circuit with a separate source of electromotive force passing current through the bulb from separate positive electrodes and utilizing the same negative as the main circuit.

Where regulation of the current is desired, as in operating storage batteries, it is not sufficient to provide a constant potential alternating-current supply, but some means equivalent to the adjustable resistance ordinarily used in direct-current systems for this purpose is necessary. This can be easily accomplished by the introduction of inductance, preferably adjustable in the main positives or in the supply. Since the voltage taken up by the resistance or inductance

is fixed as the difference between the supply voltage and the direct-current potential by changing the ohmic value of this "resistance" or backing, we, of course, alter the current strength.

Physical Explanations of Short Circuits in Converters— The general assumption or hypothesis upon which the reactions of the vapor apparatus are explained in the early part of this paper needs some amplification in connection with the converter. There is a tendency for the negative electrode resistance to fail in one of the positive electrodes in some types of bulbs during the time that it is impressed with a negative voltage thus causing a short-circuiting of the supply. One way to eliminate this difficulty is to interpose around the electrode a screen to obstruct a direct line from the non-operative positive electrode to the negative electrode or to the bath of the current between the negative and the other positive electrodes. Furthermore, this tendency is very much reduced by the elimination of the last traces of foreign gases or vapors originally in the bulb. This action can be easily explained if we assume, as already described in connection with the arc in air, that positive ions accumulating on the surface of a positive electrode under electric strain will cause the negative electrode starting resistance to fail.

Thus we may assume that a part or the whole of the residual gas (as distinguishable from mercury vapor) remaining within the bulb becomes ionized by the operation of the converter. Then the electrons will be attracted to the operating positive electrode, while the positive ions will be attracted to the other positive electrode since that is at a lower potential than the negative, where they may be capable of initiating a short-circuit. The introduction of the screen above mentioned will evidently prevent the positive ions from reaching the negatively charged positive electrode since they are attracted thereto in straight lines and will be held by the force of attraction against the surface of the screen. If there be an excessive quantity of ions, however, some of them may find their way around the shield, especially in view of repulsion by those initially accumulated on the screen, and finally cause a short-circuit.

The writer wishes to make an apology for the very incomplete and rather heterogeneous nature of the information given in this paper, but the very great amount of space and effort that would be required for giving a complete discussion of this apparatus is prohibitive, and it is hoped that such as is given will be of value.

Much information which has been published elsewhere has been used here for the sake of having such data consistently stated and collected in one place.

ELECTRICITY FOR CANALS IN GERMANY.

The United States vice-consul at Hanover, Germany, reports to the Government at Washington that the Siemens and Halske Company are testing a new method of electric traction on the Teltow Canal. The original trials of electric traction on this canal made use of tractors built in such a way that they could run in either direction. This plan seemed satisfactory, and a new system has been worked out. The new motors operate in one direction only, and a track for them has been laid on each side of the canal. The weight of the motor is distributed so that about six-tenths of it rests on the land side of the track. The motor runs on three axles, the front two being mounted on a swiveling truck. Both axles of this truck are driven through gears by two 10-horsepower direct-current motors. Power is supplied to the motors at 550 volts, series-parallel control being employed. Running unloaded, the motor makes a speed of a little over three miles an hour under series control and about double this running with the two motors in parallel. The towing line is controlled by a 1-horsepower motor, which drives the drum upon which the line is wound. There is also a motor for controlling the towing pole through which the line is carried.

INDUSTRIAL.

REVOLVING EXPLOSION MOTOR.

By Max. A. R. Brunner, C. E., Chicago.

All internal combustion motors have the drawback that the cylinders become so hot that an artificial cooling is necessary. For this reason all stationary gas engines and most of the automobile motors are provided with water jackets through which cooling water circulates.

In this country, however, the air cooled engine has been introduced and is coming into use more and more. The usual way to cool the heated metal parts is by increasing the radiating surface through means of integral cast flanges, ribs, pins, etc., against which the natural air draft, augmented by a strong air current from a fan, is blown. An entire departure from this typical cooling method is represented by an automobile motor illustrated herewith.

"It spins like a top," say the makers of this revolving motor, and, indeed, when in full motion it resembles a large top. The principle is simply that not the motor but the crankshaft is stationary, consequently the cylinders rotate around the latter, and by their great speed through the air act like a fan, thereby cooling themselves.

The mechanism is shown in Fig. 1, representing the smaller three cylinder type and Fig. 2 of the five cylinder type. Three castings, each representing a complete cylinder with combustion chamber and valves, and also one-third of the crank case are bolted together at three points and form the revolving element. The center of the crank case contains the crankshaft 8 (Fig. 1), which is immovably fixed and around which the pistons and gears revolve. (See Fig. 3.) The action of the pistons will be understood by reference to Fig. 2. As you stand at the rear of the vehicle, with

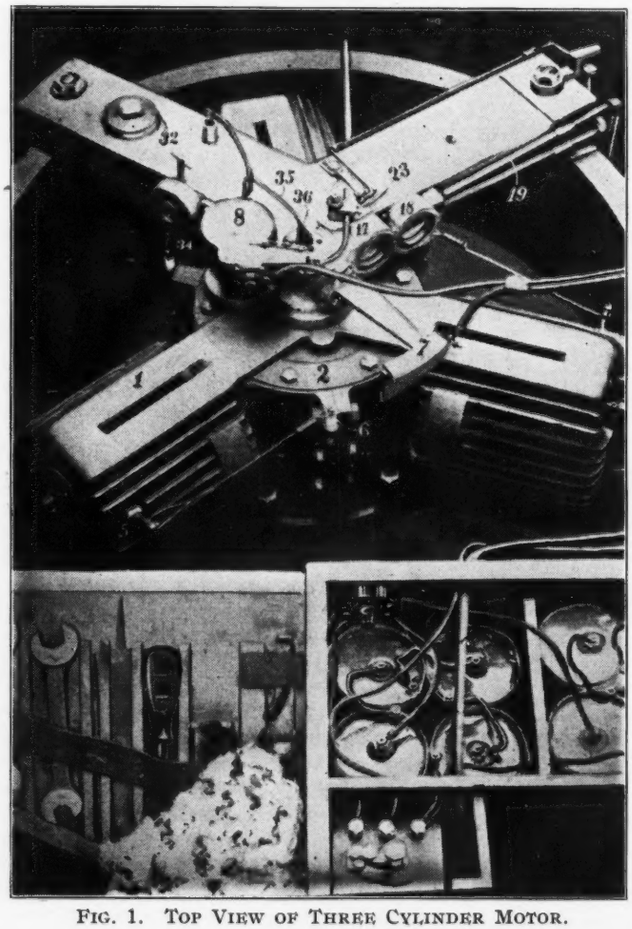

Fig. 1. Top View of Three Cylinder Motor.

the lid raised, you are in position to see (if the cylinders were transparent) just what this illustration shows. In each cylinder is a cast piston C1, having five rings. All the pistons are connected with a single crank pin of very large proportions, by connecting rods C2, having a bronze bushing at the piston end and interlocking each other around a bronze bushing at the crank end. The connecting rods, with the pistons at their outer end swing around the stationary wrist

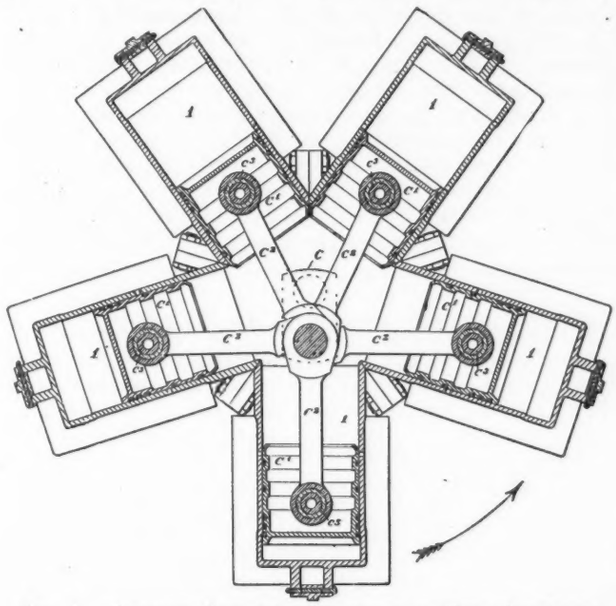

FIG. 2. SECTION THROUGH CYLINDER OF FIVE CYLINDER MOTOR.

pin in perfect mechanical balance. The wrist pin, C4, being eccentric to C, the pistons are caused to reciprocate back and forth in the cylinders at each revolution of the revolving element, although the speed and direction of motion of the mass of the pistons does not change or stop and return at each dead center, as with the ordinary motor. In the four cycle principle the complete operation consisting of suction, compression, explosion and exhaust, occupies two complete revolutions of the cylinders; there being an odd number (as 3 or 5) the explosion occurs in perfect rhythm in each alternate cylinder as it passes from A to B. It will

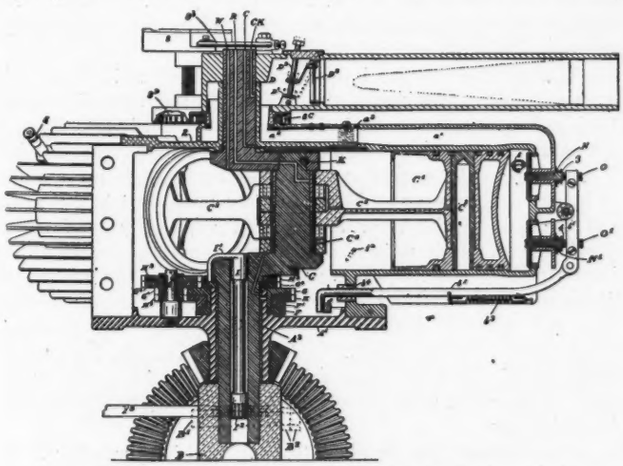

FIG. 3. SECTIONAL SIDE VIEW OF ENGINE AND TRANSMISSION.

be observed that with five cylinders there is always one cylinder on the explosion stroke, thus giving a constant torque, which is not the case with three or four cylinder motors.

The crank case 2 is confined below the flange, as Fig. 3 shows, and a small bevel gear, which also is seen at the bottom of Fig. 4. Through this wheel the power is transmitted to a horizontal axle and then through clutches and speed regulating transmission to the driving wheels.

The great advantage of this unique motor, especially for vehicles, is the fact that the heavy masses of the cylinder and the crank case represent a great momentum and thus perform compression, exhaust and suction easily without a flywheel. Also the cylinders, owing to their peculiar arrangement, form wings and produce an excellent circulation of air around the heated metal parts, thus doing away with the necessity of a fan. Where the heat is greatest at the cylinder head and valves the cooling is also most efficient, as these parts rotate around a greater circle, and, of course, with greater speed. When the motor revolves the air is caught in the center and is thrown with great velocity toward the periphery. It rushes along the cylinder walls, which are provided with longitudinal ribs to increase radiating surface. The circulation on the rear side of the cylinders is just as rapid as on the forward side. The air is in contact with all sides of the cylinder and is thrown off by centrifugal pressure while atmospheric pressure forces fresh air to take its place. The velocity of the air along the flanges is about 8 feet per revolution. At a motor speed of 700 revolutions per minute the air circulation would be equivalent to a vehicle speed of one mile per minute. The motor may be run for any length of time with the vehicle standing still.

The ignition of this engine is also unique and regulated automatically. In Fig. 1 5 contains the spark plugs, which are connected with the pin 6 by a wire; 6 is mounted on porcelain to insulate it from connection with the crank case 2. The pin (3 or 5 in number) slides at each revolution along the stationary bracket 7, thus taking the current from it; 7 is connected with the contact breaker 8 and the high tension conduit 10.

Oiling of all parts of the motor proper is cared for by an automatic positive feed pump. A surplus of oil accumulat-

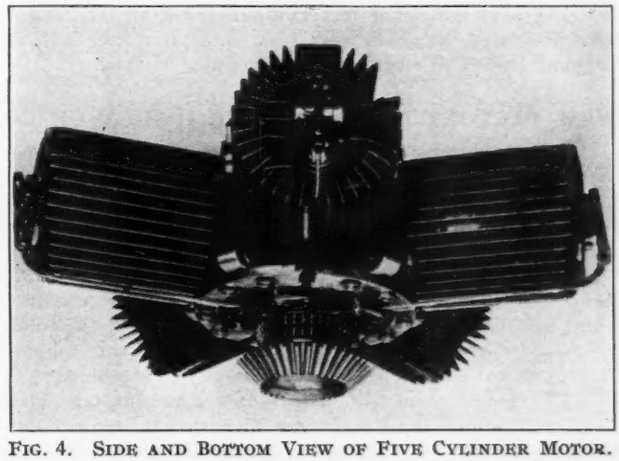

FIG. 4. SIDE AND BOTTOM VIEW OF FIVE CYLINDER MOTOR.

ing in the crank case is thrown to the wall (as milk in a separator), where it finds two holes on each side of the inwardly projecting cylinder and oils the pistons; thus the latter are lubricated at five equa-distant points. Centrifugal force assists in forcing the oil along the pistons their entire length.

Because of the velocity of the cylinders passing through the air a muffler of the ordinary automobile type may be entirely dispensed with. Auxiliary exhaust ports uncovered by the pistons let out the high terminal pressure against baffle plates, which dissipate the exhaust gases in a rapidly receding volume of air. The discharge acts upon the air like a skyrocket and not as a gun. There is also no back pressure and waste of power.

There are many things which are entirely different from the ordinary automobile construction, influenced by the peculiar design of the motor. One such feature is closing the valves by centrifugal force instead of heavy springs. It has

been found that this overcomes wear on the valve as operated by cams and gears.

Revolving the cylinders horizontally around a vertical axis allows any oil that may have found its way into the pistons to drain back into the central crank case when the motor is stopped. Attempts to revolve gasoline cylinders around an horizontal axis have proved failures, partly because the oil would drain into the cylinder that was lowest when motor was stopped.

Centrifugal force throws the heaviest part of the charge (which is the richest) to the end of the cylinder surrounding the spark plug, enabling the ignition of a charge that would be too weak to ignite in the ordinary motor.

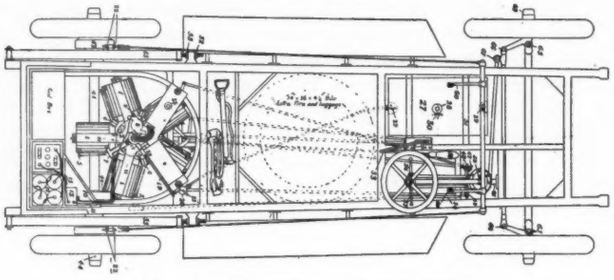

FIG. 5. CHASSIS OF AUTOMOBILE.

There is also a surprising absence of noise and vibration at all speeds of the engine. The gyroscopic effect of a heavily, rapidly revolving flywheel (such as the cylinders form) in a horizontal plane exert a tremendous force in that direction to prevent the body of the car overturning or rocking violently on rough roads.

The smaller model, with three 5x5-inch cylinders, develops from 20 to 25 horsepower, while the other type is rated 40 to 45 horsepower. The cylinders in both cases are the same size.

The first vehicle of this kind was built as far back as 1898 and later such cars have been entered in long-distance reliability tours in which they successfully finished.

NEW FACTORY OF THE LOCKE INSULATOR CO.

The rapid expansion of the business of the Locke Insulator Mfg. Co., of Victor, N. Y., has taxed to the utmost all the facilities of the old power plant, until at the present time the construction of a new and larger one has become imperative.

The new building, for which foundations have already been laid, is to be 90x90 feet, of approved concrete construction; one side being parallel to, and 15 feet below, the tracks of the New York Central & Hudson River Railroad, enabling hard and soft coal to be unloaded directly to the bunkers.

The boiler room, which measures approximately 45x90 feet, will contain 600 horsepower in horizontal tubular boilers, hand fired, with a mixture of buckwheat and soft coal, necessary draught being provided by a large engine-driven fan.

Engines, generators and high tension testing transformers will occupy the remainder of the building. There will be two power units, one for day load and a smaller one for night load, the demand for power being practically continuous. The smaller unit of 60 kilowatts capacity is made up of a Skinner engine running at 300 revolutions per minute, direct connected to a 3-phase 60-cycle 440-volt alternator. The larger unit, a low-speed Corliss, will be direct-connected to a 3-phase 60-cycle 440-volt alternator of 150 kilowatts. These two machines will supply light, power and current for testing all through factory, as well as supply power for street and residence lighting in the village of Victor.

The plant has been laid out for the most economical working under the peculiar conditions existing in an electrical porcelain pottery, and while the present plans as outlined will provide ample power for present needs, provision has been made for future increase.

RECENT ORDERS FOR NATIONAL AIR BRAKE EQUIPMENTS.

Chicago City Railway Co., Chicago, Ill.; United Railways of San Francisco, San Francisco, Cal.; Oakland Transit Co., Oakland, Cal.; Spokane Traction Co., Spokane, Wash.; Metropolitan Street Railway, Dallas, Texas; Rapid Transit Railway Co., Dallas, Texas; Dallas Consolidated Ry. Co., Dallas, Texas; San Diego Elec. Ry. Co., San Diego, Cal.; Worcester Consolidated St. Ry. Co., Worcester, Mass.; Michigan United Railways, Kalamazoo, Mich.; Twin City Rapid Transit Co., Minneapolis, Minn.; Chattanooga Railways Co., Chattanooga, Tenn.; York Street Ry. Co., York, Pa.; Memphis St. Ry. Co., Memphis, Tenn.; Birmingham Ry., Light & Power Co., Birmingham, Ala.; Knoxville Ry. & Light Co., Knoxville, Tenn.; Pensacola Electric Terminal Ry. Co.

All orders for the above roads have been taken within the last thirty days, during which time this apparatus has been on the market and approximate four hundred equipments.

"HORNSBY-AKROYD" OIL ENGINES.

The De La Vergne Machine Company, foot East 138th street, New York, reports the following among other recent orders received for "Hornsby-Akroyd" oil engines: Central New England Ry. Co., Hartford, Conn., 7 horsepower, geared to pump; F. J. Stokes Machine Co., Philadelphia, Pa., 25 horsepower; The Hastings Pavement Co., New York City, 16 horsepower; The W. F. Norman Sheet Metal Mfg. Co., Nevada, Mo., 50 horsepower; Union Ballast Co., New York City, one 20 horsepower and one 32 horsepower; D. P. Forst & Co., Trenton, N. J., 13 horsepower; Webb Wire Works, New Brunswick, N. J., 32 horsepower; Messrs. J. W. Lippincott, S. P. Scott and Max Meyer, Little Rock, Ark., 50 horsepower engine to drive a De La Vergne ice machine.

NEW WATER POWER PLANT TO SUPPLY THE CITY OF QUEBEC, CANADA.

An important addition to the developments of water powers, with which the Province of Quebec is well supplied, has been undertaken by the Quebec Railway, Light & Power Company. Up to the present time, this company has derived power from the famous Montmorency Falls, but this has proved inadequate for present needs, especially in the winter season when the water is low. Additional power has therefore become necessary so that the present development will supply an every day requirement.

The city of Quebec has apparently recovered all its old time prosperity, and, with the arrival of the new Canadian Pacific Express trains and the construction of the Grand Trunk Pacific, a large demand for additional power has set in.

Owing to the conformation of the banks, it is impossible to increase the power at Montmorency itself, but half a mile above the falls the river lends itself admirably to further development, for it widens and forms a natural reservoir in which to store surplus water and to provide for the season of drought. The company has erected there, according to the plans of Mr. E. A. Evans, Chief Engineer and General Manager, a dam 84 ft. high, the highest in Canada, for such a purpose. The dam is 67 ft. 4 in. wide at the base and 12 ft. wide at the crest, with a reservoir capacity of 52,000,000 cubic feet of water.

The contract for the plant to develop this power has been awarded to Allis-Chalmers Company's Canadian representatives. The equipment to be furnished will consist of a 1500 kilowatt alternating current generator, driven by a 2,225 horsepower turbine water wheel. The new power house is expected to be in operation by early December of this year.

The Quebec Railway, Light & Power Company has under consideration a further development at the Three Falls, two miles up the river, which, when developed, will provide for future demands for power.

News Notes.

FINANCIAL.

San Francisco, Cal.—One check for $13,729,000, the largest amount in a single payment for years, has passed between Banker Hellman and the Union Trust Company, for account of the Spring Valley Water Company. An agreement had been entered into between the Spring Valley Water Company and Isaias W. Hellman for the sale and purchase for $14,500,000 par value of the general mortgage 4 per cent bonds of the Spring Valley Water Company. Mr. Hellman agreed to pay for the bonds on or before August 31, 1906, and the Spring Valley Water Company agreed that the money received from that source be paid to the Union Trust Company of San Francisco for the purpose of paying off all of the first, second and third mortgage bonds of the Spring Valley Water Company's works, thus making the general mortgage bonds a first mortgage on all the property of the water company.

San Francisco, Cal.—An assessment of 5 cents per share has been levied on the capital stock of the Western Gas & Power Company, payable October 1st, delinquent October 5th, sale day October 25th.

San Francisco, Cal.—The long-drawn-out litigation in the federal and state courts over the validity of the Brown's Valley Irrigation District bonds will soon be settled. A committee representing the directors of the district has been holding a conference in this city with the attorneys of the bondholders for several days, and it has been reported that they had arrived at a satisfactory agreement and that the bondholders will realize on their investment in the course of a month.

San Francisco, Cal.—By telegraphic report from New York it is stated that plans for utilizing the water power facilities in California have been formed and include the formation of a California company, to be known as the Feather River Power Company, with an authorized capital of $25,000,000. This company is to take over the stock of the Eureka Power Company, Golden Gate Power Company and the Western Power Company of California. The stock of the Feather River Power Company is to be held in turn by the Western Power Company of New Jersey, which is to have authorized capital of $18,000,000, of which $6,000,000 will be preferred stock. In the plan as outlined the Feather River Power Company is to issue $25,000,000 first mortgage 5 per cent gold bonds, to be secured by first mortgage on the properties of the several power companies.

Bakersfield, Cal.—It is reported that the Independent Oil Producers' Agency has made or is making a contract with the Associated Oil Company at a better figure than the existing one—18c per barrel. It is not stated on what figure the new contract is being made, but it is more than 18c.

Los Angeles, Cal.—The Union Home Telephone Company has filed its certificate of the creation of a bonded indebtedness with the County Clerk. The capital stock of the corporation is $10,000,000. There are 10,000 $1,000 bonds bearing 5 per cent. The indebtedness will be secured by a trust deed executed to the Title Insurance and Trust Company of this city.

Monrovia, Cal.—The people will be asked for $80,000 for an issuance of bonds to increase the supply of water to the city by building a storage dam in Maple canyon, sinking wells and laying a new system of mains all over the city.

San Francisco, Cal.—Fred A. Stock, vice-president of the San Francisco, Vallejo & Vaca Valley Electric Railway & Steamship Company, has arrived in this city from Paris and has announced that arrangements have been completed for the financing of the new road. Mr. Stock says that Henry Dupont, a banker of Paris, has taken the entire bond issue of the company, consisting of $2,500,000 in 6 per cent bonds.

INCORPORATIONS.

San Francisco, Cal.—The Hendy Electrical Company has been incorporated with a capital stock of $50,000 by Walter G. Anderson, John H. Hendy, Charles G. Gardner, F. J. Behneman and A. C. Webber.

San Francisco, Cal.—The Feather River Power Company has been incorporated with an authorized capital stock of $25,000,000. The syndicate managers are Edwin Hawley, F. H. Ray, J. N. Wallace, A. C. Bedford and Philip Stockton of Boston.

Butte, Mont.—The Montana Reservoir Company has been incorporated by A. J. Davis, W. A. Clark, Jr., Henry Mueller, H. W. Turner and J. L. Templeman, all of Butte, with a capital stock of $1,500,000, and will do business in Madison, Meagher, Lewis and Clark, Gallatin and Cascade counties.

San Francisco, Cal.—The National Conduit & Cable Company has been incorporated with a capital stock of $200,000 by J. P. McQuade, Cornelius Gallagher, E. S. Perot, W. H. Lewis and G. J. Jackson. Place of business, State of New York.

TRANSMISSION.

Los. Angeles, Cal.—A new company, with a capitalization of $2,500,000, to be known as the Ventura County Power Company, has been organized. The companies included in the merger are the Ventura Water, Light & Power Company, the Oxnard Light & Water Company and the Santa Paula Electric Company. The object of this consolidation is to erect a transmission line beginning at a sub-station to be located at Castaic, at which the Edison company's Kern River transmission line will be tapped and extended west and south for distributing electric energy for light and power to the cities of Oxnard, Ventura and Santa Paula, as well as to the entire section of Ventura.

Corona, Cal.—Earl McDonald has accepted a position with the Shasta Power Company and has left for Redding, where he expects to be engaged for the next year in construction of a large water power electric plant.

Chihuahua, Mexico.—The contracts for a large dam and power plant on the Concho river above Santa Rosalia have been awarded. The Northern Electric Power Company, with a capital of $10,000, is back of the enterprise.

Fresno, Cal.—James T. Boyd of San Francisco is planning to start a steam power plant in Fresno in competition with the San Joaquin Light & Power Company.

Porterville, Cal.—A. G. Wishon has arrived to inspect the progress of the work on the power plant. He was accompanied by the chief engineer, G. O. Newman, who made a general inspection for the future work on the plant. Mr. Newman said he has now seventeen electric plants in hand for H. E. Huntington and has already completed eight. There will be seven constructed in the San Joaquin Valley, of which three will be on Tule river, one at Doyle's, one at the forks and one near the clubhouse, and the others will be in Southern California. A million-dollar steam plant for generating electricity has just been completed at Fresno with 1,600 horsepower. With all the power plants that will be constructed, Mr. Newman says they will not have enough power for the purposes they intend to use, and will have to construct steam plants.

TELEPHONES AND TELEGRAPHS.

Tonopah, Nev.—General Manager Adams of the local telephone and telegraph company has just returned from a trip into the southern country. He has been engaged in selecting the pole line for the extension of the wires to Greenwater from Bullfrog. He reports that the line will be more easily constructed than was at first supposed, and it is probable that communication between Tonopah and Greenwater will be established in less than two months' time.

Berkeley, Cal.—The central offices of the local branch of the Sunset Telephone & Telegraph Company were changed from the old quarters on Shattuck avenue at midnight, September 4th, to the new plant on Bancroft Way. The new equipment of the exchange has been fitted up at an outlay of $75,000, and is one of the best equipped central stations in the cities about the bay. Eight relay multiple switchboards have been added.

ILLUMINATION.

Pasadena, Cal.—City Attorney J. Perry Wood has given out that the electric light plant will be installed in the near future and declares contracts with the lighting company void.

Ogden, Utah.—The Riverside Milling Company will at once proceed to erect a gas producing plant at their mills on Washington avenue for the purpose of manufacturing gas for production of fuel to run their mills. Nels Knudsen is one of the proprietors. A building will be erected adjoining the mill.

Santa Barbara, Cal.—The Merchants' Mutual Light & Power Company has announced that it will extend its line to Coleta.

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Cross Arms
Carter & Co., George E.
Estabrook Co., A. F.
Electric Appliance Co.
The Lindsley Bros. Co.

Dynamos and Motors
Allis-Chalmers Co.
Brooks-Follis Elec. Corp.
California Electrical Works
Century-Klein Elec. Co.
Electric Manufacturing Co.
Fort Wayne Electric Works
General Electric Co.
Kilbourne & Clark Co.
Northern Electrical Mfg. Co.
Standard Electrical Works
Stanley-G. I. Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co
Wagner Elec. Mfg. Co.
White Mach. Co., H. S.

Elevators
Van Emon Engineering Co.
Willamette Iron & Steel Wks.

Electric Blowers
Northern Electrical Mfg. Co.

Electric Grinders
California Electrical Works.
Northern Electrical Mfg. Co.

Electrical Instruments
Cole Co., John R.
Cutter Co., The
Electric Appliance Co.
Fort Wayne Electric Works
General Electric Co.
Holabird, Reynolds&Sayles Co.
Kilbourne & Clark Co.
Stanley-G. I. Elec. Mfg. Co.
Standard Electrical Works.
Westinghouse Elec. & Mfg. Co
Weston Elec. Instrument Co.

Electrical Machinery
California Electrical Works.
Northern Electrical Mfg. Co.
Occidental Mach. and Eng. Co.
Standard Electrical Works.
White Machinery Co., H. S.

Electric Polishers
Northern Electrical Mfg. Co.

Electric Railway Appliances
Lord Electric Co.
Ohio Brass Co.
Pierson, Roeding & Co.

Electrical Supplies
Aylsworth Co., H. G.
California Electrical Works.
Standard Electrical Works.

Electric Motors
Aylsworth Co., H. G.
California Electrical Works.
Northern Electrical Mfg. Co.
Standard Electrical Works.

Electric Ventilating Fans
California Electrical Works.
Northern Electrical Mfg. Co.

Engines, Boilers, Heaters, etc.
Allis-Chalmers Co.
Hunt, Mirk & Co.
Moore & Co., Chas. C., Inc.
Occidental Mach. and Eng. Co.

Engines, Boilers, Heaters, etc.,-con.
Ohmen Engine Works
Platt Iron Works
Standard Elec. Works
Tracy Engineering Co.
Westinghouse Machine Co.
Willamette Iron & Steel Wks.

Engines, Gas and Gasoline
Allis-Chalmers Co.
Moore & Co., Chas. C., Inc.
Occidental Mach. and Eng. Co.
Westinghouse Machine Co.
Woodin & Little

Engineers, Chemical
Smith, Emery & Co.

Engineers and Contractors
Brooks-Follis Elec.Corporation
Byllesby & Co., H. M.
California Electrical Works
Cannon, Edward F.
Century Klein Company
Cole Co., John R.
Copeland, Clem A.
Cory, C. L.
Hunt, Dillman,Meredith&Allen
Doble Co., Abner
General Electric Co.
Hall, Leon M.
Hippely & Meyers
Hunt, Mirk & Co.
Jackson, D. C. & W. B.
Kilbourne & Clark Co.